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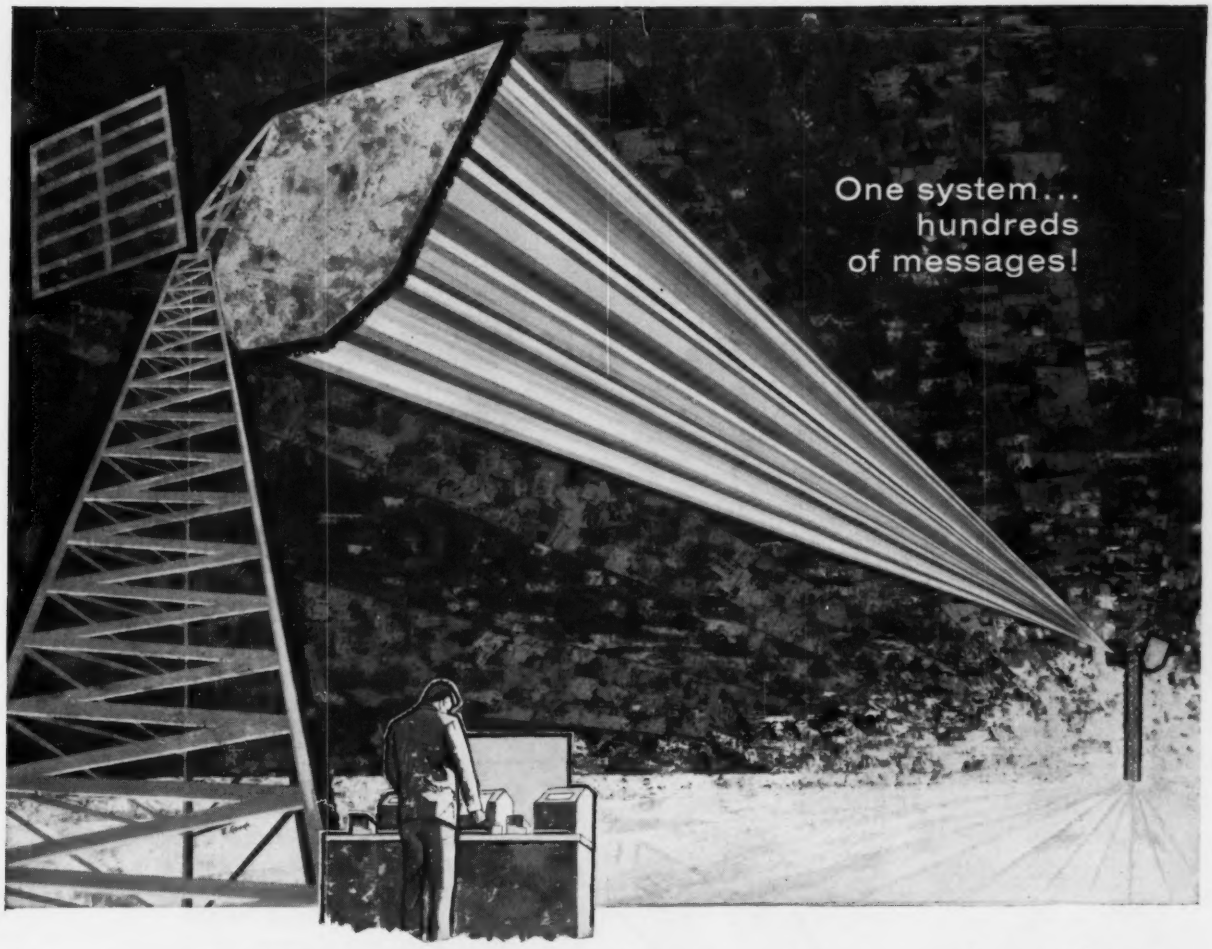

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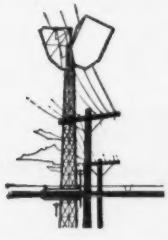

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OCTOBER 1961 VOLUME 27 No. 1

Editorial: More than the Minimum 7

The Concept of Time: From the Greeks to Einstein 12
by Alan L. Goodman, EP '64

The United Engineering Center 17
by Mary Ann Huber, CE '63

Pyroceram 21
by David S. Kessler, ME '62

A Report by the Editors: The Engineering Student Counsellors . . . 28

President's Message 32

Alumni Engineers 33

College News 38

Technibriefs 42

Fifty Years Ago in the Engineer 47

Stress and Strain 50

COVER, Ball bearing parts and pistons made of Pyroceram are now being tested.
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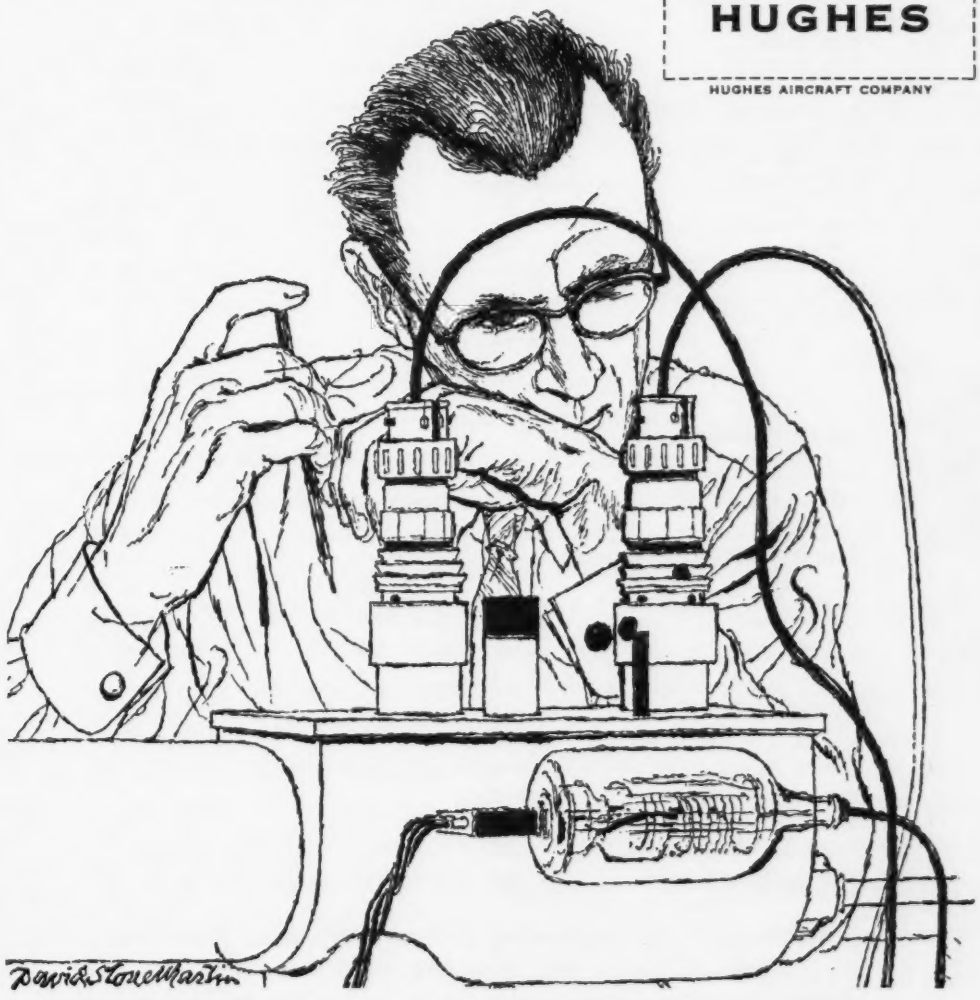

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Editorial . . .

MORE THAN THE MINIMUM

Cornell University can provide you with much more than the minimum education you will receive by limiting yourself to the mere satisfaction of its academic requirements. If your years at Cornell are spent only completing the specifically assigned work a great deal will have been missed. I speak now not only of the elements which go into what is termed "broadening" one's education. The role of guest lecturers, concerts and the like in the attainment of this goal should be obvious to you, their value is significant and irreplaceable. However for most of us there is also room for much broadening even within the confines of our strictly academic work. The achievement of this part of an education will require individual initiative. It will require the developing of an interest in one's work which extends beyond the day's assignment, even beyond the next prelim. Such an interest will allow the student to use more fully the facilities which surround him. Its development can result from the same type actions that will accompany its further pursuance.

A first step towards this goal may be taken by doing some browsing in the library. Reading books, other than assigned text, on a field which interests you is very worthwhile. The current periodicals of your future profession should become part of your regular reading. They will provide you with a knowledge of the recent occurrences in industry and research lab and will make the "academic process" more meaningful.

The Student Chapters of the professional engineering organizations also serve to foster something above the "academic requirements" incentive. Their programs are planned with this aim of supplementing the classroom and should be taken advantage of.

As in all your endeavours at Cornell, here too a sense of balance or proportion is necessary. That time must be budgeted between assigned work and leisure activities is a familiar bit of advice. Somewhere between the two, however, lies the field of non-assigned studies. Make time for it, you won't regret it.

—Spar

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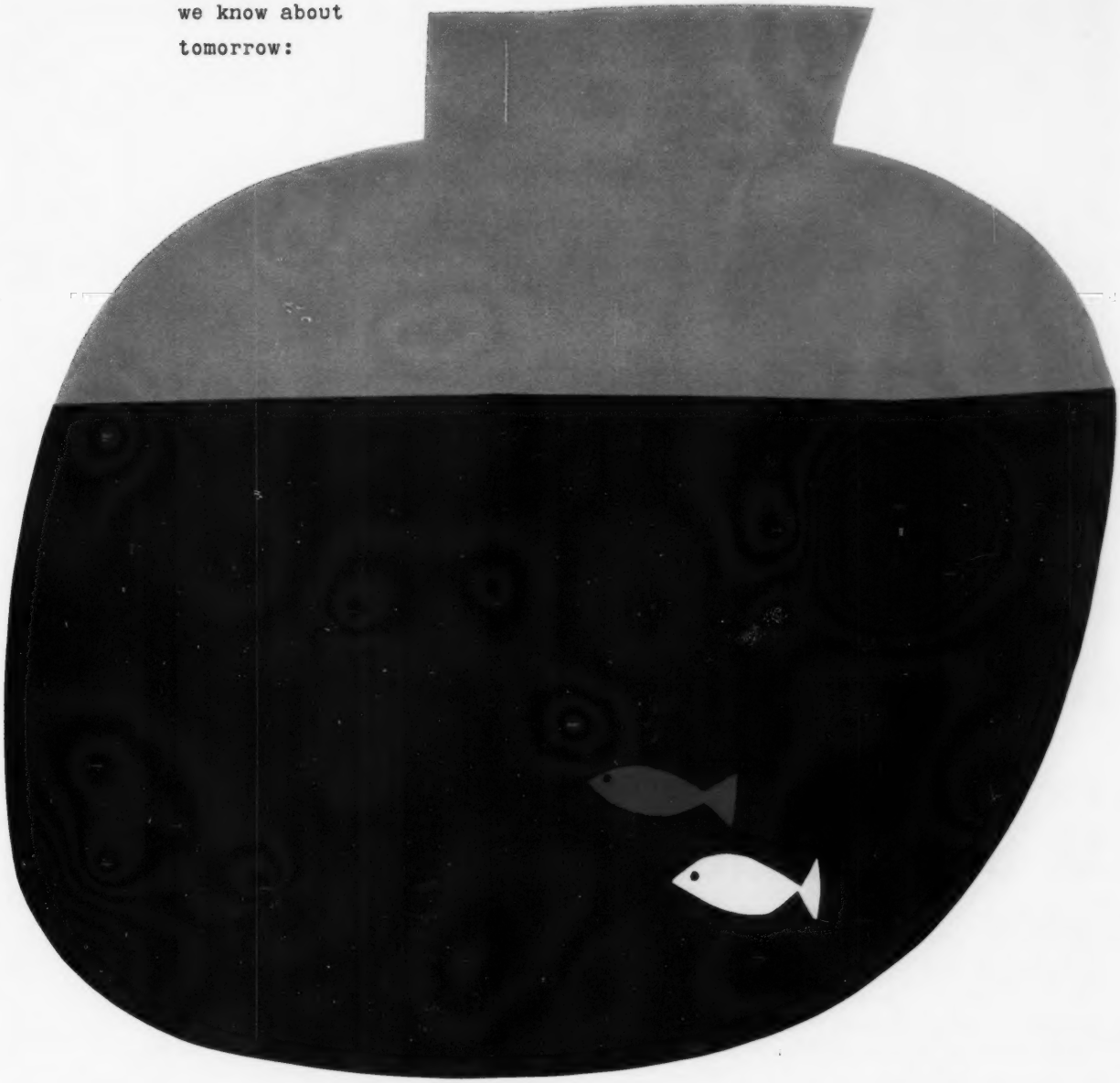

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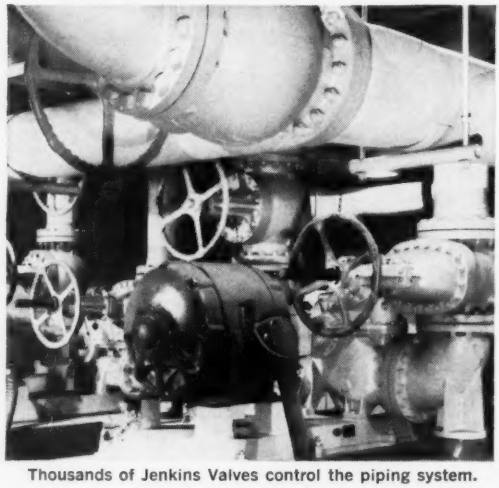

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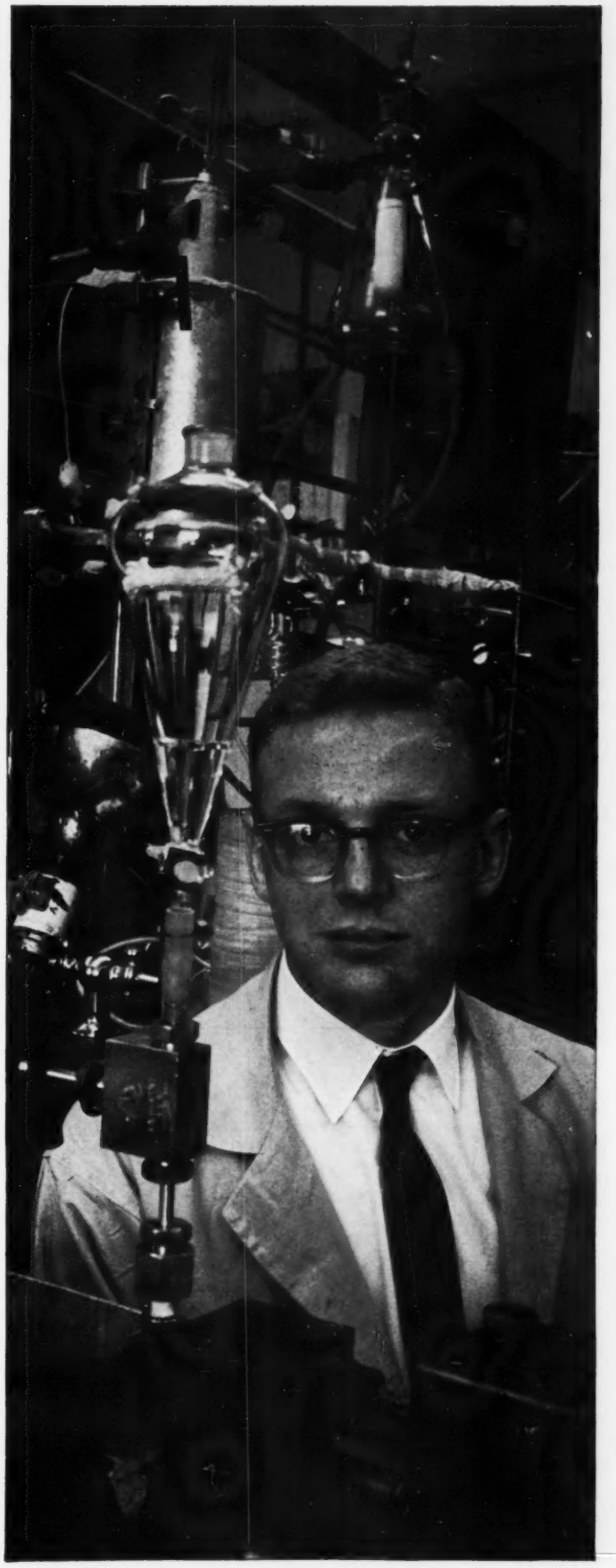

Some straight talk about a career at American Oil

by Roger Fisher

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Roger Fisher, B.Ch.E. from Cornell and Ph.D. candidate from Princeton is one of many young scientists and engineers at American Oil shaping the future for himself, his Company and the industry. At 26, he has earned a Fulbright Scholarship and will take a year's leave of absence to continue his graduate research on solids mixing at the University of Osaka, Japan.

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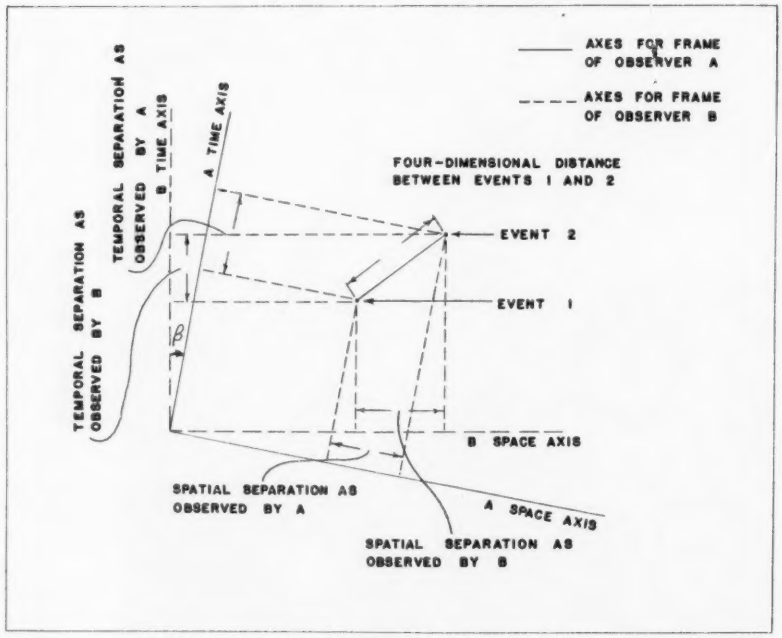
THE CONCEPT OF TIME: FROM THE GREEKS TO EINSTEIN

by Alan L. Goodman, EP '64

Time travels in divers paces with divers persons. — *As You Like It, act III, scene 2*

Time has no division to mark its passage, there is never a thunderstorm or blare of trumpets to announce the beginning of a new month or year. Even when a new century begins it is only we mortals who ring bells and fire off pistols. — *The Magic Mountain, Thomas Mann*

Conjecture concerning the concept Time, in past ages relegated to musty documents of unworldly philosophers, has moved to the forefront in modern-day physics and in the conversations of many laymen. The major question concerning Time which has arrested the minds of philosophers and physicists from the initial periods of civilization to the present day is this: Is there an Absolute Time, a time which passes at the same rate for all objects and inhabitants of the universe "like a large, slow-flowing river whose current is the same for all points along its banks?"[1] Or is there in reality no Absolute Time, but only Relative Time, a time which flows at different rates for different observers?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A TIME AXIS
B TIME AXIS
B SPACE AXIS
A SPACE AXIS
SPATIAL SEPARATION AS OBSERVED BY A
SPATIAL SEPARATION AS OBSERVED BY B

Fig. 1: Spatial and temporal separations between two events are dependent upon the choice of the observer.

Viking Press

In every age there have been adherents of each concept.

The existence of the element Time was recognized as early as the fifth century B.C. by a Greek philosopher, Heraclitus. He conceived of the constant flow and unidirectional properties of Time. "You cannot step twice into the same river."[2] That is, the position in the river (spatial location) may be identical, but the water located there (temporal location) has changed.

Plotinus, a third century Roman philosopher, was a chief exponent of the subjective view of Time. He maintained that Time is the result of the movement of the Soul, not the product of motion of material objects. "The Soul produced succession as well as act. . . . Time, then, is contained in differentiation of Life; the ceaseless forward movement of Life brings with it unending Time. . . . Would it, then, be sound to define Time as the Life of the Soul in movement as it passes from one stage of act or experience to another? Yes."[3] In the fourth century Saint Augustine stated, "In thee, O my mind, I measure times."[4] That is, the duration of the "memory or expectation" of an event determines whether the duration of the event itself is long or short.

A second school of ancient philosophers maintained a more objective conception. The "temporal process" is determined by concrete events and sensible objects rather than by acts of the Soul. Thus Time has a measurable aspect which is distinct from its relation to Life. Some ancients considered Time as being totally independent of Soul—as being the underlying current of the universe. It is of interest to note that in these two schools of ancient philosophy are summarized the two trends of thought which have dominated the concept Time through the ages.

The second major problem concerning Time is whether it is characterized by continuity or atomicity (the state of consisting of discrete quantities). Of the two giants in the realm of ancient philosophy, one, Plato, emphasized the atomic structure of Time, while the other, Aristotle, stressed the continuous nature of Time. We shall return to this concept of time continuum later.

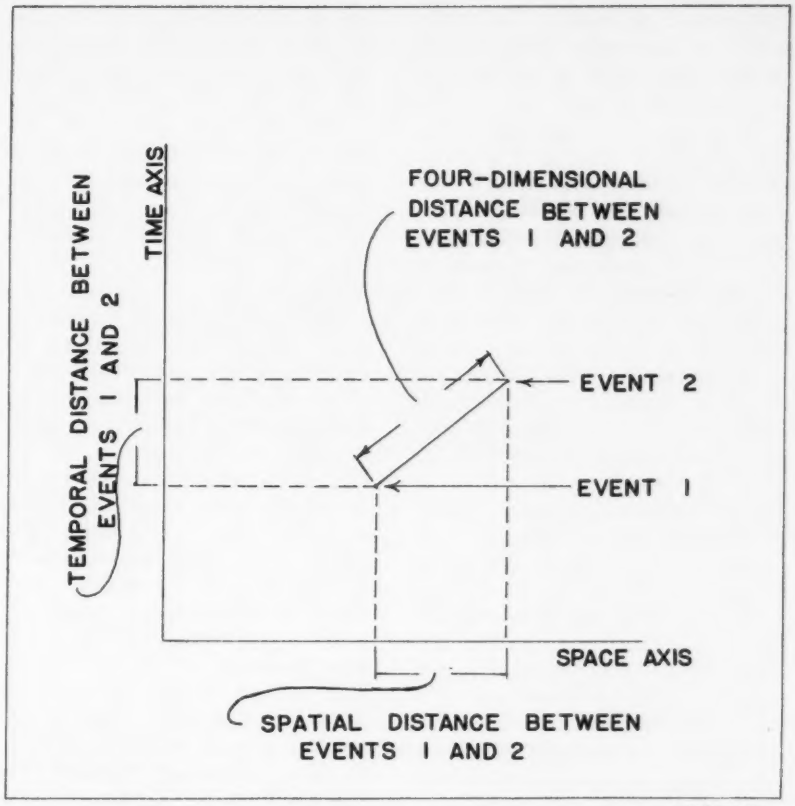

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Fig. 2: Distance and duration between two events expressed as projections of the more fundamental four-dimensional separation.

Later Views

The post-medieval period heralds the entry of Physics into the arena of contestants wrangling over the meaning of Time. Cusanus realized that the possibility of absolute motion depends on the existence of an absolute center of the universe. Having satisfied himself that there could be no absolute center, he concluded that there can be no absolute motion. Bruno, a sixteenth century Italian, further hypothesized that the lack of absolute motion implies the absence of any absolute time. Bruno also contended, however, that all phenomena of nature run their course according to exactly the same general laws in all parts of the universe. In Bruno's philosophy, therefore, we discover the basic tenets of Einstein's Special Theory of Relativity. The major disagreement is that Bruno maintained the atomocity of Time, while Einstein upheld the continuous character of Time.

In the annals of scientific history Newton is distinguished as the chief exponent of the concept of Absolute Time. He recognized the relativity of Time as regards the individual person and even as regards an individual world. This Relative Time is the product of human sense perceptions and human measurement systems. However, he also insisted upon the reality of an equable time, a steady flow independent of human sensations, material events, and motion. Just as Relative Time is a product of human sensation, so, Newton believed, was Absolute Time the "divine sensorium" of the Deity. (Newton's theological convictions had substantial influence over his scientific beliefs.)

He distinguishes between the two conceptions of Time as follows: "Absolute, true and mathematical time of itself, and from its own nature, flows equably without regard to anything external . . . relative, apparent, and common time, is some sensible and external (whether accurate or unequable) measure of duration by

the means of motion, and this which is commonly used instead of true time, such as an hour, a day, a month, a year."[5]

With this brief introduction to the concept of Time as it was understood through the ages, let us now consider the revisions generated by the advent of modern physics, primarily the theories of Albert Einstein.

Einstein rejected the doctrine of Absolute Time, a steady flowing river, as well as the doctrine of Absolute Space. He maintained that much of the obscurity that has enveloped the Theory of Relativity is a result of our failing to realize that sense of time is similar to sense of color. They are both types of perception. As the eye is a prerequisite for the recognition of color, so does the distinction between a second and an hour depend upon events to mark them. Einstein adhered to the principle of Subjective Time. The personal experiences of an individual form a series of events arranged according to the criterion of "earlier" and "later." It is this succession of personal experiences which comprises our own subjective time, a thing which is not measurable.

The reader may insist that our personal experiences may be referred to a clock, thus providing an objective concept of Time. However, the time intervals produced by a clock "are by no means absolute quantities imposed on the entire universe by divine edict."[6] The Theory of Relativity informs us that the clock intervals are not invariant.

Whitehead, twentieth century British philosopher and mathematician, remarks that since time measurements are relative to the observer's body and its motion, rather than being relative to the mind of the observer, the Theory of Relativity does not uphold a subjective concept of Time.

Space-Time Continuum

As though it were not difficult enough to comprehend the theories of past philosophers and physicists, today we are told that there is no such "animal" as Time. Nor does such a "creature" as Space exist. Instead we must consider a Space-Time Continuum, a curious hybrid which is more than space plus time. Henceforth, Minkowski (the mathematician credited with the development of four-dimensional relativistic geometry) declared, "Space and Time as independent things must sink to mere shadows, and the only things which can preserve some sort of subsistence is a kind of union of the two."[7]

Before attempting to explain the nature of our curious hybrid, let us first examine the interconvertibility of Time and Space. Although a spatial distance is usually measured in terms of feet or meters, it is sometimes specified by giving the time required to traverse the distance by means of a certain form of transportation.

Since the velocity of light is an invariant quantity of nature it forms a natural standard for space-time conversions. Thus astronomers measure spatial distances in terms of light-years, that is, the number of years that light takes to traverse the distance. Similarly, we can speak of the "light-mile," that is, the time necessary for light to travel one mile. (For the mathematically inclined, one light-foot corresponds to 1.1×10^{-9} seconds.)

The fundamental distance between any two events is their four-dimensional space-time distance, an invariant quantity. This distance is given by Einstein's formula: $d = \sqrt{x^2+y^2+z^2-(ct)^2}$

The abolition of Space and Time as separate quantities renders necessary the consideration of four-dimensional distances. Each point in four-dimensional space corresponds to an event and is given by the combination of a spatial position and a time-date. Einstein originally believed that the distance between two such events or points can be calculated by a generalization of the Pythagorean Theorem. (Relativity considers this four-dimensional distance to be of more fundamental significance in the relations between events than either of the separate space and time separations.)

Although space and time are intimately connected in Einstein's theories we can not obliterate all distinctions between the two and turn a clock into a yardstick or vice-versa. Therefore, our new formula is not as simple as one might expect. Einstein advanced the following form:

$d = \sqrt{x^2+y^2+z^2-(ct)^2}$.

Minkowski transformed Einstein's seemingly illogical proposal so that four-dimensional geometry would more closely resemble Euclidean geometry. By treating the time co-ordinate as a purely imaginary quantity he obtained: $d = \sqrt{x^2+y^2+z^2+(ct')^2}$, where $t' = ti$, and "i" is $\sqrt{-1}$.

The following conclusions may be drawn from this formula. If the spatial distance is greater than the temporal distance, the space-time separation is real. Such a distance may be converted into a purely spatial separation. Similarly, if the temporal distance is greater than the spatial distance, the four-dimensional separation is imaginary and may be converted into a purely temporal separation.

Distance Relationship

What, then, is the relationship between the secondary distances, spatial and temporal, and the fundamental four-dimensional distance? A relatively simple method for depicting the relationship is this: Consider the space and time distances as projections of the four-dimensional distance onto an arbitrary set of co-ordinate axes. (See figure 1.) Rotation of the co-ordinate axes shows us how spatial separations may be partially transformed into durations, and vice-versa.

Although the four-dimensional distance between any two events is invariant with respect to any observer, the spatial and temporal separations are wholly dependent upon the choice of the observer. This is easily illustrated by our co-ordinate axes. (See figure 2.) Assume that planet A is moving uni-

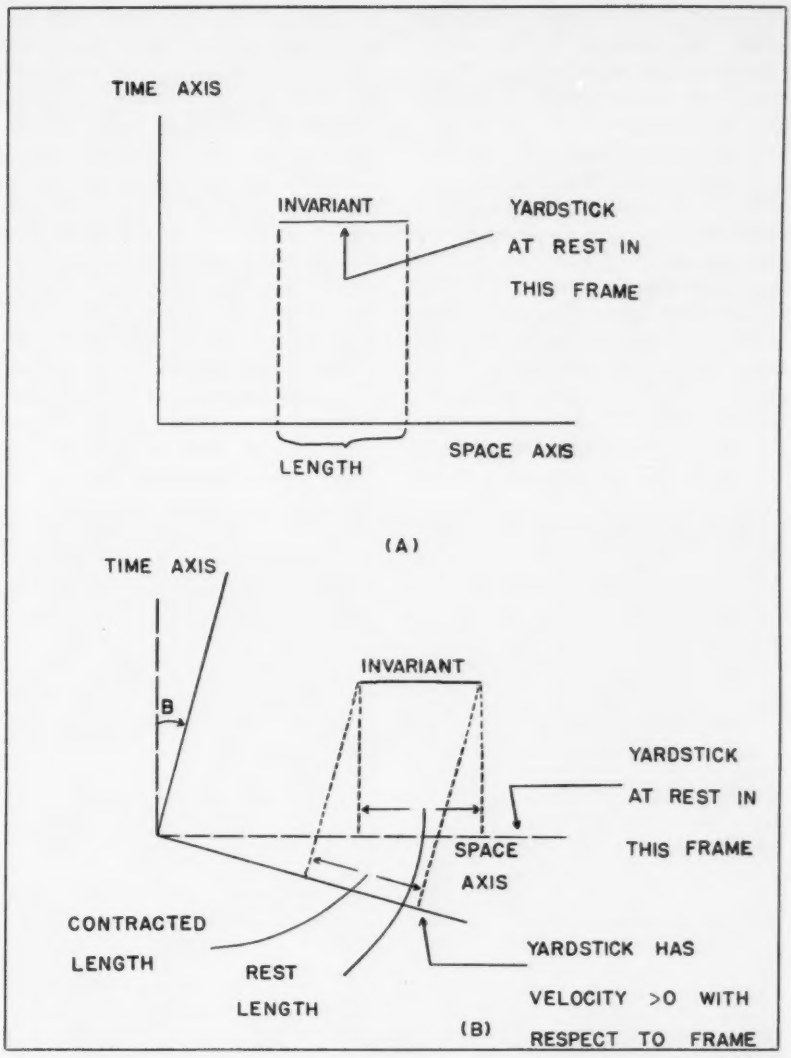
formly with respect to planet B. Knowing the position of the axes for frame B, the position of the axes for frame A is determined by rotating the initial axes by an angle β. (β is a function of the velocity of A with respect to B.)

Therefore, the duration between two events depends on our choice of observer. We conclude, then, that time itself must actually flow at different rates for different observers.

Perhaps a concrete example will serve to give more meaning to the four-dimensional distance concept. Imagine a man eating dinner in a diesel-drawn dining car. Consider the two events of the man eating his appetizer and the same man eating his dessert. From the point of view of the waiter on the train, these two events occur at the same place. The spatial distance to him is zero. From the point of view of a group of switchmen situated at stationary points along the railroad track, the two events occur at different locations. According to them the spatial separation is not zero. Since the equivalent space-time distance is invariant with respect to any observer, and since the spatial separation is different as seen by the waiter and the switchmen, we must conclude that the time separation between the two events is different for each observer. (The exact relationships between the separations as seen by each observer are given by the well-known Lorentz transformations.) Once again we see that time flows at different rates for different observers.[8]

In a similar manner the Principal of The Relativity of Simultaneity may be derived. Two events occurring at the same moment, but at different locations, as seen by one observer, will be considered as happening at different moments as seen by a second observer in a state of motion relative to the first observer. This principle is an unavoidable consequence of the four-dimensional geometry as it has been formulated.

The reader may have already discovered that our coordinate axes easily explain the oft-publicized phenomena of length contraction and time dilation. Figure 3a illustrates a yardstick at rest in the frame shown. Its rest-length is projected onto the space axis. Figure 3b shows the same yardstick as observed from a second frame moving uniformly past the first. The projection of the rod onto the second space axis is shortened. (The fractional change in length is given by the Lorentz transformations.)



Don Milstein

Fig. 3: Length Contraction: The top diagram depicts the length of a rod as seen by an observer in a frame at rest with respect to the rod. This is the maximum, or rest length. The bottom diagram illustrates the contracted length of the rod as seen by an observer in a frame in motion with respect to the rod.

The rotation of our co-ordinate axes also affects the measurements of time intervals. Because of the imaginary character of the time dimension, the time intervals will expand when the spatial distances decrease. That is, an observer on one frame of reference will discover that all physical, chemical, and biological processes will be slowed down on a second frame moving past him uniformly. In fact, the Lorentz transformations tell us that the time dilation would be infinite for a system moving by us uniformly with the velocity of light. Time would cease to flow.

We must remember, however, that this cessation of all natural processes is an observation peculiar to us alone. For the inhabitants of that second system will notice no change whatsoever in the motion of their clocks or the duration of natural phenomena. (The situation is the same as if all objects in our universe were decreased in size overnight by some strange cosmic occurrence. Since all our

measuring rods and standards would be affected in the same manner as all other objects, there would be no means of detecting the alterations.)

The General Theory of Relativity introduces the effects of a gravitational mass on time. Einstein's conclusions greatly modified existing theories of gravitation. Today this phenomenon is considered to be nothing more than the effect of the curvature of the four-dimensional space-time universe in the vicinity of the mass responsible for the gravitational field. The result is that all natural processes will run slower in the vicinity of a large mass. For example, if a physical process takes exactly one second on earth, 1.000002 seconds (as measured by us) will elapse when the identical process occurs on the sun. (This has been verified by comparing the periods of vibration of identical atoms on each body.)

Einstein has bequeathed to us a space-time concept which Bertrand Russell believes is, "from a philosophical and imaginative point of view, perhaps the most important of all the novelties that he has introduced."[9] We exist in a four-dimensional space-time continuum in which each event, or the existence of each minute mass, is represented by its own unique world-point, that is, a particular point in three-dimensional space at a particular moment. As the peculiar nature of Time allows no retrogression, we are pushed forward along the time axis, each of us forming his unique space-time line or world line in the continuum which is our universe.

. . . Fortunate is the astronomer peering through his glass. His vision extends farther and farther into space; countless beams of light bring to him the events and records of past millions of years. For in our Space-Time World to gaze outward into space is but to behold unrecorded eons of time.

FOOTNOTES

1. James Coleman, *Relativity for the Layman,* Mentor, New York: 1954, p. 66.
2. Horton Sheldon, *Space, Time and Relativity,* University Society, New York: 1932, p. 15.
3. Louise Heath, *Concept of Time,* University of Chicago Press, Chicago: 1936, p. 42.
4. *Ibid.,* p. 53.
5. *Ibid.,* p. 88.
6. Lincoln Barnett, *The Universe and Dr. Einstein,* Mentor, New York: 1950, p. 52.
7. Alexander J. Gunn, *The Problem of Time,* George Allen and Unwin Ltd., London: 1929, p. 210.
8. George Gamow, *One Two Three . . . Infinity,* Mentor, New York: 1947, p. 92.
9. Bertrand Russell, *The ABC of Relativity,* Mentor: New York: 1958, p. 42.

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THE UNITED ENGINEERING CENTER

by Mary Ann Huber, CE '63

Engineering in America has a new home—a stainless steel and glass tower rising on the west side of New York's United Nations Plaza. The new United Engineering Center, to be dedicated this November, provides a headquarters for the activities of some 19 professional engineering societies and research institutes, and serves as a center for the accumulation and diffusion of engineering knowledge. Among its facilities are meeting and exhibition rooms, office space, and the most complete engineering library in the United States. The use of these facilities will enable the societies to better serve their world-wide memberships.

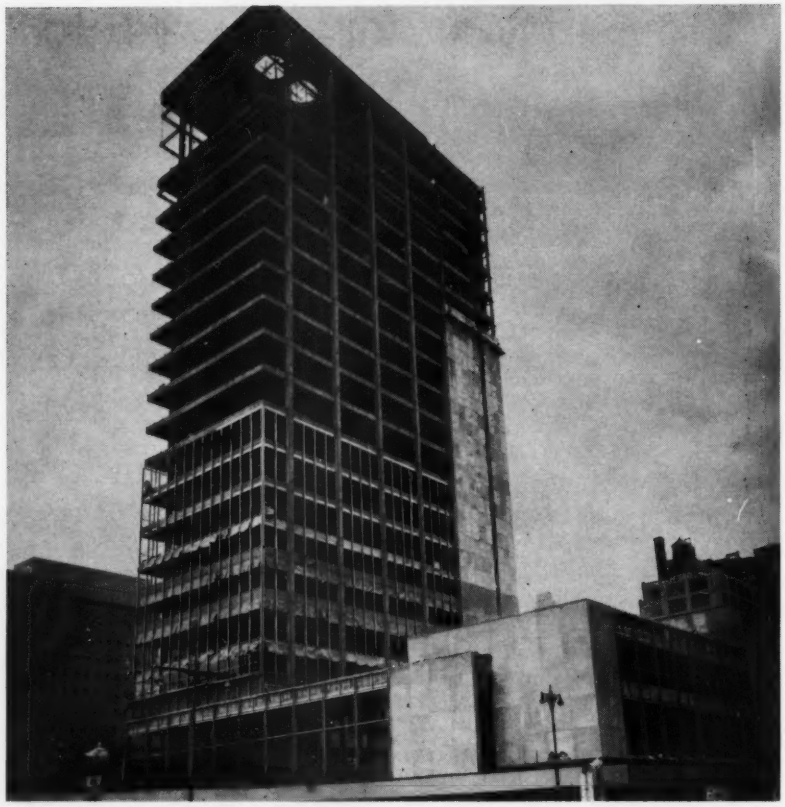
Engineering Societies Building

The idea of bringing the professional engineering societies together under one roof is an old one. For over fifty years, many of the societies that now occupy the United Engineering Center have been located in the Engineering Societies Building on 39th Street, New York. This building was given to the engineering profession by Andrew Carnegie, who declared that "it would give me great pleasure to give, say, one million dollars to erect a Suitable Union Building for you all, as the same may be needed." This gift was made to the United Engineering Society, composed of representatives of ASME, AIEE, ASCE, and AIME, and founded for the "advancement of engineering arts and sciences in all their branches, and to maintain a free public engineering library."

All photos courtesy of **Civil Engineering**

The new United Engineering Center, home of 19 professional engineering institutions, will be formally dedicated in November. The UEC is located on United Nations Plaza in New York City.

The Engineering Societies Building, given to the engineering profession by Andrew Carnegie, served the needs of the professional societies for more than fifty years.



The UEC had reached this stage of completion by November, 1960. The all-welded steel framework had been erected, and the exterior walls of steel, glass, and limestone were under construction. The first two floors house exhibition halls, meeting room, library, and other public facilities, and the tower contains the offices of the engineering societies.

The Engineering Societies Building, dedicated in 1907, contained office space occupied by the ASME, AIEE, AIME, and several other societies, and other facilities for common use by these groups. Especially noteworthy were a 1000-seat auditorium, fully equipped for scientific demonstrations, and the Engineering Societies Library. This library has grown from the original pooled literature collections of the founder societies to more than 180,000 volumes, and has now been moved to the United Engineering Center. In 1917, three additional floors were added to the original thirteen-story building when the ASCE joined the societies already located there.

In the following decades, however, the groups acquired a membership of more than 300,000 and the staff required to serve such a membership grew to about 400. In the early 1940's, the opinion had already been advanced that the Engineering Societies Building would soon be hopelessly crowded, and in 1951 a report of the United Engineering Trustees outlined the deterioration of the building and expressed the hope that a new one could be built. At that time, all the available space in the building was occupied, some was doubled up, and additional space was wanted by societies hoping to make their headquarters there. Thus, the engineering profession had outgrown its home; the need for a new one was becoming pressing.

First Steps

When the United Engineering Trustees decided to acquire a modern engineering center, the first problem to be solved was one of location. Offers of land, existing facilities, cooperation, and various other forms of aid were received from several cities, among them Philadelphia, Pittsburgh, Washington, Boston, and Chicago. It was felt, however, that New York's transportation arrangements, convention sites, and other advantages outweighed its disadvantages of high real estate cost and the necessity for multi-story construction. The site chosen, considered one of the best pieces of land in the city, is located on First Avenue, between 47th and 48th Streets, and covers almost one acre.

The firm of Shreve, Lamb, and Harmon, designer of the Empire State Building, was appointed for the architectural design of the United Engineering Center (UEC), and Seelye, Stevenson, Value and Knecht was selected for the structural engineering. From their offices, a design emerged for a building of twenty stories, the first two covering the entire site, and the rest forming the office tower, with the top two reserved for mechanical equipment. The cost of the entire project was estimated to be greater than twelve million dollars. Financing came from several sources, principally from the donations of individual society members and gifts from industry. Sale of the Engineering Societies Building brought two million dollars.

Several features of the build-

ing's basic design are particularly worthy of mention. The Center is a steel-framed, all-welded structure, faced in Indiana limestone, glass, and stainless steel. It was intended not only to satisfy engineering's present needs, but also to accommodate the needs of the future. For this reason, the designers provided a plan for the addition of a second tower, twelve stories high, when expanded society activities require more office space. Two extra elevator shafts are also included. The 19th and 20th floors of the present tower house equipment for the elevators, air conditioning, water, and ventilation. Such unsightly appurtenances have often remained exposed on the rooftops of New York City buildings.

In keeping with the building's clean, uncluttered exterior lines is the internal design of the tower. Only one row of interior columns is used; thus the tenants are assured of large, unbroken areas of office space. The side of the tower facing United Nations Plaza, cantilevered out eleven feet from the first row of columns, provides an ideal spot for executive offices.

Ground was broken for the Center on October 1, 1959, with ex-President Herbert Hoover, an honorary member of four societies housed in UEC, as chief participant. Assisting Mr. Hoover was a freshman engineering student from Hawaii, representing the engineers of the future. Steel erection progressed rapidly, at the rate of more than two floors per week, and had already reached the 13th floor when the building's cornerstone was laid in June, 1960. With exterior work completed, interior partitions erected, and finishing touches applied, the UEC was ready for occupancy by September 1, 1961, and for its dedication next month.

A Visit to UEC

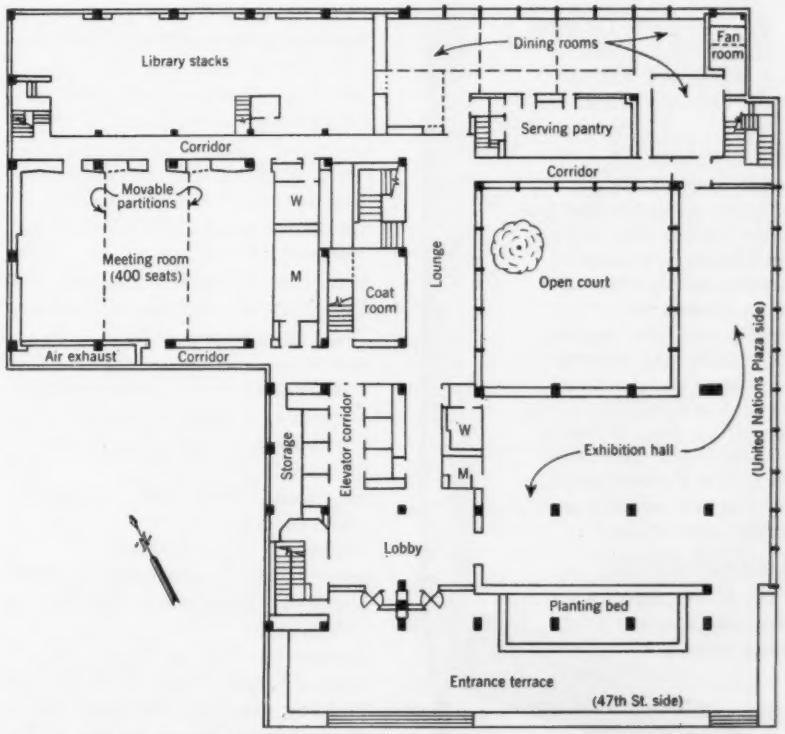
What might a society member see on a typical visit to the United Engineering Center? A clear idea of the advantages and services provided by the new building may best be gained by following along on such a visit. We enter through the main doors on 47th Street from a landscaped terrace slightly above street level and proceed into the marble-walled lobby. To our right is the exhibition hall. Its glass window-walls enclose ample floor space for large exhibits which might be staged during conventions, and for changing displays throughout the year. The inner window-wall permits a view of an open-air courtyard one floor below, with benches, shrubs, and a tree; a pleasant place for visiting engineers to meet and chat.

Proceeding toward the opposite side of the building, we pass the lounge and stop for a look at the main meeting room. This room is suitable for gatherings of up to 400 people, and is furnished with modern equipment including a chalkboard and projection facilities. The meeting room may be easily divided into three smaller places of assembly by the use of two folding partitions. Also on the first floor are dining rooms and a serving pantry for small society functions. Employees in the building may have lunch in a spacious cafeteria on a lower level.

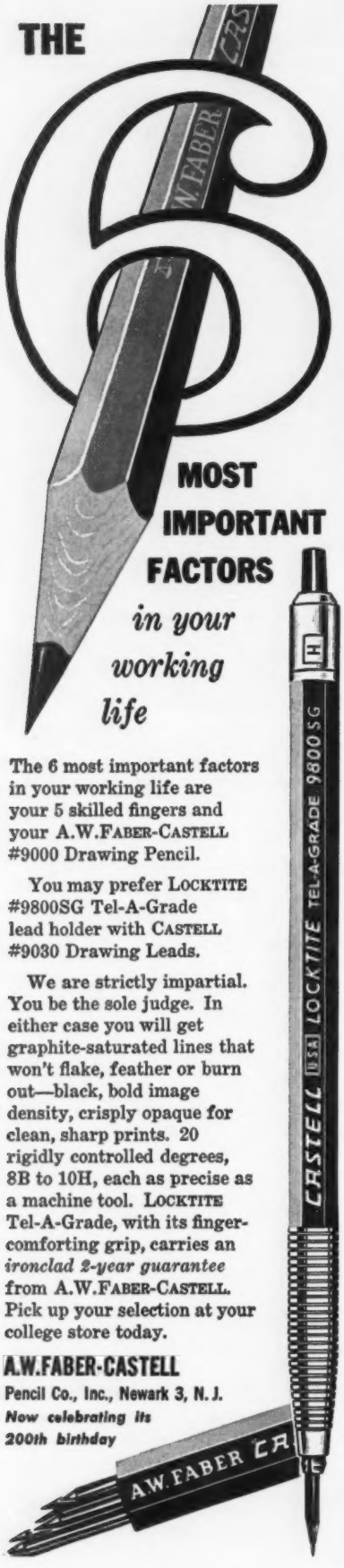
Returning to the main corridor, we take one of the building's four self-service elevators to the second floor, the new location of the Engineering Societies Library. The main reading room accomodates eighty researchers, who may use the library's huge book collection or any one of more than 3,300 periodicals and serial publications the library currently receives. This collection, expected to eventually reach 225,000 volumes, is stored on five stack levels served by a small elevator. The reading room is open to all visitors, including those who do not hold membership in one of UEC's tenant societies. In addition to the use of its reading room, the library performs valuable special services. These include the making of bibliographies, literature searches, and English translations from more than ten other languages; and the photoprinting or microfilming of library material. Members of the Founder Societies (AIChE, AIEE, AIME, ASCE, and ASME) are permitted to borrow books for home use, either in person or by mail.

Society Headquarters

After viewing the facilities shared by all the UEC occupants, the typical visitor will undoubted-



A floor plan of UEC's first floor shows some of the facilities that will be shared by its tenants.



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The Hon. Herbert Hoover breaks ground for UEC in October, 1959. With Mr. Hoover are a Hawaiian engineering student who assisted in the ceremony, and Mr. Andrew Fletcher, president of United Engineering Trustees, owners of the building.

ly wish to stop in at the headquarters of his own professional society or of one of the research institutes. A glance at the building directory will indicate his destination, and the visitor may proceed to the offices of:

American Institute of Chemical Engineers
American Institute of Consulting Engineers
American Institute of Electrical Engineers
American Institute of Industrial Engineers
American Institute of Mining, Metallurgical, and Petroleum Engineers
American Society of Civil Engineers
American Society of Heating, Refrigerating, and Air Conditioning Engineers
American Society of Mechanical Engineers
American Welding Society
Engineering Foundation
Engineering Index, Inc.
Engineers Council for Professional Development
Engineers Joint Council
Illuminating Engineering Society
Municipal Engineer of the City of New York
Society of Women Engineers
United Engineering Trustees
Welding Research Council

The institutions occupy office space ranging in size from a single room to three full floors. The 15th and 16th floors are presently unoccupied.

On a visit to a typical Founder Society, a member finds offices for the Society's executives, for accounting, membership records, public relations, and the many other operations necessary to keep a far-flung membership active and informed. A conference room provides space for board meetings and other gatherings. The Proceedings and Transactions of the several societies are edited in their UEC offices, as are their official publications, such as *Civil Engineering*, *Mechanical Engineering*, and *Electrical Engineering*.

A headquarters for the activities of America's professional engineers . . . a repository and a diffusion center for engineering information . . . the new United Engineering Center is this and much more. It is in itself a beautiful example of the achievements of those whose societies it houses.

ACKNOWLEDGMENTS

The author wishes to express thanks to the following people: Mr. J. Lessley of Engineering Societies Library, for his assistance in use of library research materials during the time when the library was preparing to move to UEC; Mr. Hal Hunt, editor of *Civil Engineering* magazine, and his staff, for their help in gathering information and illustrations.

PYROCERAM

by David S. Kessler, ME '62

Corning Glass Works

Harder than steel or brass, Pyroceram can score both materials in a scratch test.

The scene is a United States rocket-launching site. A rocket has just been launched and its surface gleams in the early morning light. Because of air friction the temperature of the rocket's metal skin rises hundreds of degrees. The nose-cone is the hottest part of the rocket, but it is substantially unaffected by the heat. It is made of a new, tough ceramic-like material called Pyroceram.

Long before glassmakers knew exactly what crystallization was, they fought to prevent it in glass. The formation of crystals in non-crystalline glass reduced the strength of the glass. But a series of scientific advances, culminating with the discovery of Fotoceram in 1953 by Dr. Donald Stookey of the Corning Glass Works, proved that the formation of tiny, internal crystals could produce exceptional properties in glass.

Since different heating schedules affected the size and density of the crystals, scientists began to wonder if the photosensitive process of Fotoceram could be bypassed and crystal growth started by heat alone. Special chemicals acting as seeds for crystal growth were added to the glass batch. With a careful schedule of heat treatment, a new substance with amazing properties was produced. It was named Pyroceram.

Pyroceram is a glass-ceramic—a substantially crystalline, inorganic material, similar in many ways to a conventional ceramic, but differing in the important feature that it is made, not by the sintering together of crystalline material by the formation of glassy boundaries, but by a controlled slow cooling process, during which crystals form in true glass. This permits the final forming of articles by conventional glass-forming techniques, prior to the process of crystallization.

Control of the crystallization implies an ability to govern the degree of crystallinity as well as the size of the crystals. This is done, generally, by dissolving in the glass some material that is foreign to the main composition and which has limited solubility in it. At some temperature, precipitation of this foreign material will take place, followed by nucleation and growth of the primary crystalline phase around the foreign substance.

Theory of Nucleation

Since nucleation is a fundamental part of the theory of glass-ceramics, it is useful, at this point, to survey past and present experimental work on nucleation together with its correlation with theory. Using this discussion as a background, it will then be possible to discuss the forming of ceramics from glass by controlled nucleation of crystals.

The equilibrium pressure-temperature diagram for a stable substance (Page 22) illustrates some of the basic principles of nucleation. All three phases—vapor, liquid and solid—are in equilibrium at point O. Curve OX is the boiling point curve, OY, the freezing point curve and OZ is the solidus-vapor equilibrium line.

Assuming that a material in the gaseous state is to be cooled to a crystalline or solid state, at constant pressure, line AP' would represent the behavior of such a material. The vapor would be cooled from A to a temperature between

B and C, slightly below the boiling point. The vapor would be supersaturated and would not nucleate spontaneously in this so-called metastable zone. It may condense to droplets on any foreign particle present, provided that the new phase will "wet" (adhere to) the particle. This type of nucleation is known as heterogeneous nucleation. The vapor may condense, on the other hand, on artificially-added droplets of the liquid phase. This is homogeneous nucleation.

If there are no foreign nuclei present, the vapor can be cooled to point C, where spontaneous nucleation and condensation to liquid takes place. Further cooling brings the liquid into another metastable zone, that between D and E. Here, crystallization does not occur, but if crystal nuclei are present, they can initiate crystal growth. Spontaneous nucleation occurs below E.

In materials such as inorganic glasses, it is possible to cool through the entire range, indicated by line AP', without nucleation. This is an important part of the definition of commercially usable glass.

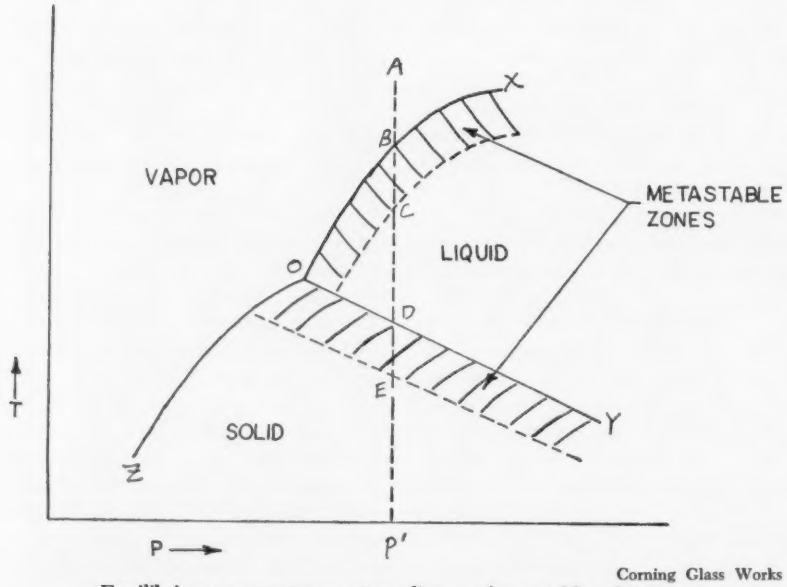
Experimental Investigations

Ostwald was among the first scientists to investigate the solubility of materials. He showed that "spontaneous crystallization takes place only in strongly supersaturated solutions and that there was a metastable zone within which no crystal nuclei could form spontaneously." The postulate that there is a metastable zone has been borne out both by experimental and theoretical investigations. Such a zone exists for condensation of some vapors, supercooling of melts and even for certain solid state transitions.

G. Tammann studied crystallization in undercooled inorganic glasses and showed that there is a metastable zone below the melting temperature by counting the number of crystals and their growth rates as functions of the degree of undercooling below the equilibrium melting temperature. He found that crystals in the metastable zone do not form at any appreciable rate unless nucleated, and that at lower temperatures, both the rate of crystal growth and the rate of spontaneous formation of crystal nuclei affect crystallization.

Tammann also found that, due to the relationship between viscosity and temperature of a material (viscosity increases as temperature decreases), materials exhibit maxima in crystal growth and nucleation rates at a certain degree of undercooling.

More recently, members of a symposium on the theory and practice of nucleation proposed that the explanation for the metastable zone is found in the fact that the tiny crystal nuclei have melting temperatures below those of macroscopic crystals. And correspondingly, the metastable zone of supersaturation in solutions is due to the known greater solubility of the smaller crystallites as compared to larger crystals.



Corning Glass Works

Equilibrium pressure-temperature diagram for a stable substance.

Heterogeneous Nucleation

For homogeneous nucleation and growth, the number and size of silver crystals precipitated from a silver nitrate solution containing a mild reducing agent can be controlled by the amount of colloidal silver added to the solution. The importance of this concept has also been confirmed for the case of heterogeneous nucleation, with the added criteria that the foreign particles must be wetted by the surroundings and that the crystals to be grown must wet the foreign crystals so that the former crystals can grow onto the foreign nuclei. All of these rules apply to inorganic glasses. The fact that there are ways of meeting these requirements is the basis for glass-ceramics.

Investigators know that all glasses are metastable below some temperature and that many compositions will crystallize quite readily. Many will even say that all glasses contain crystallites. They take the view that this is not a necessary condition because in many glasses the rate of spontaneous nucleation is negligible under ordinary cooling conditions. These glasses (with crystallites) can be troublesome if a glass-ceramic type product is desired because the most probable temperature for occurrence of nucleation in these glasses is usually quite close to the most probable temperature for rapid crystal growth. A situation in which homogeneous nucleation takes place (thus resulting in a small number of random-sized crystals, some of which reach large dimensions before other parts of the body are even nucleated!) is to be avoided in making useful glass-ceramics.

A partial solution is presently being used in the production of Pyroceram. Strong, fine-structured crystalline bodies are made by using nucleating agents to control

formation of crystals. The developmental steps that led to this solution follow.

Photosensitive Glass

Until a short time ago, research men thought that gold, silver and copper dissolve in glass as colorless atoms which, during heat treatment, accumulate as crystals. In 1937 it was found, on the assumption that the process might really be one of reduction of dissolved ions (rather than atoms) by other ions which became reducing as the temperature decreased, that exposure to X-rays or ultraviolet light resulted in a rapid and complete "warming-in" of copper ruby (that is, copper ruby crystals accumulated at crystal formation centers). After failing to sensitize opal glass in the same manner, scientists found that by substituting cerium, an optical sensitizer, for the reducing ions, glass would "warm-in" if exposed. The experiments were done with gold and the glasses became known as photographic glasses.

Later work cleared up the behavior of photosensitive glasses to the extent of indicating the number and sizes of the crystal centers present. Absorption coefficients and light scattering properties of these glasses were also studied.

If one varies the exposure and the heat treatment of a photosensitive glass, he can control the number and sizes of precipitated crystals. In addition, various exposures produce various colors.

Fotolite, Fotoform, and Fotoceram

Earlier work confirmed that gold or silver nuclei could be used to catalyze the crystallization of the glass itself. This was first done with a lithium metasilicate glass, the first in a line of photosensitive opal glasses called Fotolite.

The gold particles must be about 75 A. in diameter before they can serve as nuclei for metasilicate because nuclei must attain substantial size on an atomic scale before they can catalyze crystallization of another phase. The threshold was found to be between 10 and 250 A. The diameter ratio between crystal and nucleus is of the order of 20 to 1000 for fine-grained glass-ceramics. Certain compositions of Fotolite showed a high ratio of solubility in HF between the opal and clear parts. As a result, any part developed throughout the thickness could be entirely dissolved away, leaving a hole. This material is called Fotoform.

Also, if the glass was heavily exposed to ultraviolet light and heat-treated after this chemical removal, a dense, hard, strong, high-temperature ceramic resulted. This is called Fotoceram.

The final step, the development of Pyroceram, was somewhat "anticlimactic." The problem was to find suitable nucleating agents to cause these same processes to occur without the need for ultraviolet light or X-ray exposure. There are, at present, only two applications of this principle because of the necessity of finding approximate compatibility between the nucleus and crystallized phase. The two applications are designated as Code 9606 and Code 9608. Both are known as Pyroceram.

Glass-Ceramic Radomes

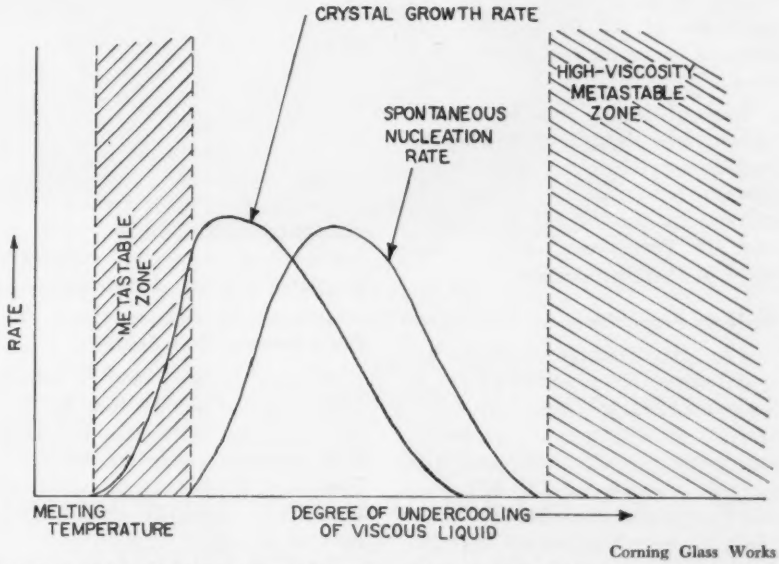
A radome is "an enclosure which permits passage of microwave radio frequencies for guidance of a missile, and protects the internal guidance equipment from its operating environment." The radome of a missile must be able to withstand high temperatures and thermal shock. It must stand up against sudden aerodynamic pressures and vibration and destructive erosion by raindrops moving at high relative velocities. The ideal radome must also fulfill minimum weight requirements and cost requirements and it must be reproducible on a large scale.

At present, three materials are used for radome applications. They are alumina ceramics, fiber glass luminates and Pyroceram Code 9606. A study of the production processes and properties of Code 9606 missile nose cones illustrates the advantages of using Pyroceram as a radome material.

The first step in the production of a nose cone involves the batch. Ingredients for the glass batch are selected for purity by chemical analysis. The raw materials, after being carefully weighed and proportioned to assure the uniformity of the parent glass, and ultimately of the crystalline product, are thoroughly blended. They are fed into the melting tank at a closely controlled rate.

Melting of the parent glass is the second step. In order to minimize contamination of the molten glass, special compound refractory "linings" are used. In the "premelt" section of the tank, heat reduces the batch to a viscous liquid. Then it flows into a chamber where bubbles are removed from the molten glass. Finally, the glass flows into the delivery end of the tank.

One of the difficulties presented by Pyroceram occurs in the de-



Corning Glass Works

Materials exhibit maxima in crystal growth and nucleation rates at a certain degree of undercooling.

livery end of the melting tank. Since Pyroceram must be melted at high temperatures, it has to be held at temperatures well above the normal range for glasses while in the delivery end. Because of this greater heat, and a lower viscosity than most glasses, the material is very fluid at the forming stage. Cooling must be controlled to prevent runaway crystal growth.

The radome is formed by centrifugal force created by spinning the mold. The glass cools quickly during forming. Internal stresses caused by the sudden cooling are removed in an annealing oven. After removal from the oven, the transparent nose-cone is visually inspected for faults.

Preliminary machining and "ceramming" follow inspection. The cone is rough ground in the finishing department. The inside surface is contour-ground to approximate size and excessive external stock is removed. The blank is then placed in a ceramming kiln and heat-treated according to a predetermined schedule. During this process nucleating agents are used in controlled crystallization. The glass is transformed from the transparent state to an opaque white state.

Final machining takes place in the grinding department. Extensive grinding is not necessary since dimensions hardly change during ceramming. The last step is to join the radome to a metal ring which, in turn, can be bolted to the body of the missile. The radome is given final inspection and then shipped.

Some of the advantages of Pyroceram radomes are: They can be manufactured quickly and easily, precise reproducibility from one radome to another is guaranteed, and all Pyroceram radomes are alike in their properties.

Radome Properties

The glass-ceramic radome has good dielectric properties over a wide temperature range. At a frequency of 10^{10} cps., the dielectric constants are 5.45, 5.51, and 5.53 at temperatures of 77, 572, and 932 degrees F respectively. These electric properties remain approximately the same until 1800 degrees F, the top operating temperature.

The radomes can withstand 2200 degrees F for short times without deforming and their low thermal expansion coefficient of 32 x 10^{-7} per degree F, compared to 41 x 10^{-7} for alumina, gives them good resistance to thermal shock.

Thermal emissivity is also high. At an altitude of 100,000 feet and a speed of Mach 6, the Pyroceram Code 9606 cone will have a mean temperature of 1300 degrees F, while the alumina cone would be at 1800 degrees F. Alumina has a higher deformation temperature than Pyroceram, but at high speeds this disadvantage is offset by the temperature variance just discussed. Pyroceram radomes can also withstand temperature gradients nearly 50 per cent greater than the high limit for alumina.

Corning Glass Works

Pyroceram has no recorded loss of strength at temperatures as high as 1470 degrees F. This Pyroceram is still rigid after furnace temperatures hot enough to melt the copper bar and to cause the steel bar to sag.

The mechanical properties of Code 9606 also meet the radome's requirements. The modulus of elasticity is 17.3 x 10^6 psi. Poisson's ratio is .245 and the flexural strength is 26,000 psi. Harder than steel or brass, Pyroceram measures 619 on the Vicker's hardness scale. The specific gravity of 9606 is 2.61 compared to 3.60 for alumina. Even though Pyroceram's flexural strength is lower than that of other materials, a strength-to-weight comparison favors Pyroceram.

Glass-Ceramic Ball Bearings

Another unusual field in which Pyroceram is being utilized is in the manufacture of ball bearings. Ball bearings, made entirely from Pyroceram Code 9608, on standard equipment, have been evaluated by several manufacturers.

Tests conducted by Corning and the ball bearing manufacturers have shown that the glass-ceramic ball bearings will operate at up to 1000 degrees F with no lubrication. It was also found that these ball bearings fail "by gradual erosion, rather than by chewing action." This is an advantage when sudden jamming of equipment could cause dangerous problems.

Pyroceram Code 9608 has the same white, opaque, fine-grained crystal characteristics as Code 9606. It was developed as a general purpose material and, as such, it can be blown, drawn as tubing, pressed and rolled. Being nonporous, it shows no increase in weight even after long submersion in water.

One of the most valuable properties of Code 9608 is its thermal shock resistance. Quarter-inch plates of the material can be heated to 1300 degrees F and plunged into ice water; the material will be unaffected.

Pyroceram Code 9608 has high mechanical strength. Flexural strength varies from 14 to 23 thousand psi for abraded pieces, depending on heat treatment. These properties, combined with its thermal properties, give this glass-ceramic a thermal shock resistance better than that of all ceramics and equal to that of fused silica.

Code 9608's electrical properties aren't as good as those of 9606. Chemically, it is less resistant to strong acids than borosilicate glasses.

Other Applications

In addition to the two applications already discussed, Pyroceram is used for range-top saucepans and skillets, which are sold under the name of Corning Ware. This new glass-ceramic is also used in the production of journal bearings which will operate without lubrication, with different metal shafts, at temperatures of 1800 degrees F. Because it offers a non-fouling surface which keeps combustion conditions in a cylinder constant, Pyroceram is being considered for use as a piston cap material. The Pyroceram piston top maintains a higher temperature than a metal piston because of its low thermal conductivity.

Pyroceram is being used for telescope mirror blanks because its

mean coefficient of expansion can be approximately zero. Telescopes operate between the same temperature limits as Code 9608. Other applications now being considered include valve parts, space and seal rings, curtain walls and structural parts for aircraft and missiles.

In concluding, it is important to note the advantages of Pyroceram over glass and alumina.

The advantages over glass are as follows:

1. Glass-ceramic can be fabricated into articles not possible when fused silica is used.

2. It can attain lower expansivities than ordinary borosilicate glasses and its modulus of rupture is above that of any glass.

3. Its surface hardness is higher.

In certain ways, the glass-ceramics have advantages over alumina:

1. The advantages of extremely low expansion coefficients have been discussed.

2. As a dielectric, Pyroceram can have low losses at high temperatures and frequencies.

3. Glass-ceramics have low elastic moduli and low conductivity.

The Corning Glass Works, producer of Pyroceram, "is directing present research toward new and better glass-ceramics to enhance these advantages and add new ones to the list." At present, the primary feature which marks Pyroceram as a major technological "break-through" is that it can be produced by conventional glass-making and glass-forming techniques into articles difficult or impossible to produce in conventional ceramics. It can also be controlled on a combination of properties, with a high degree of precision.

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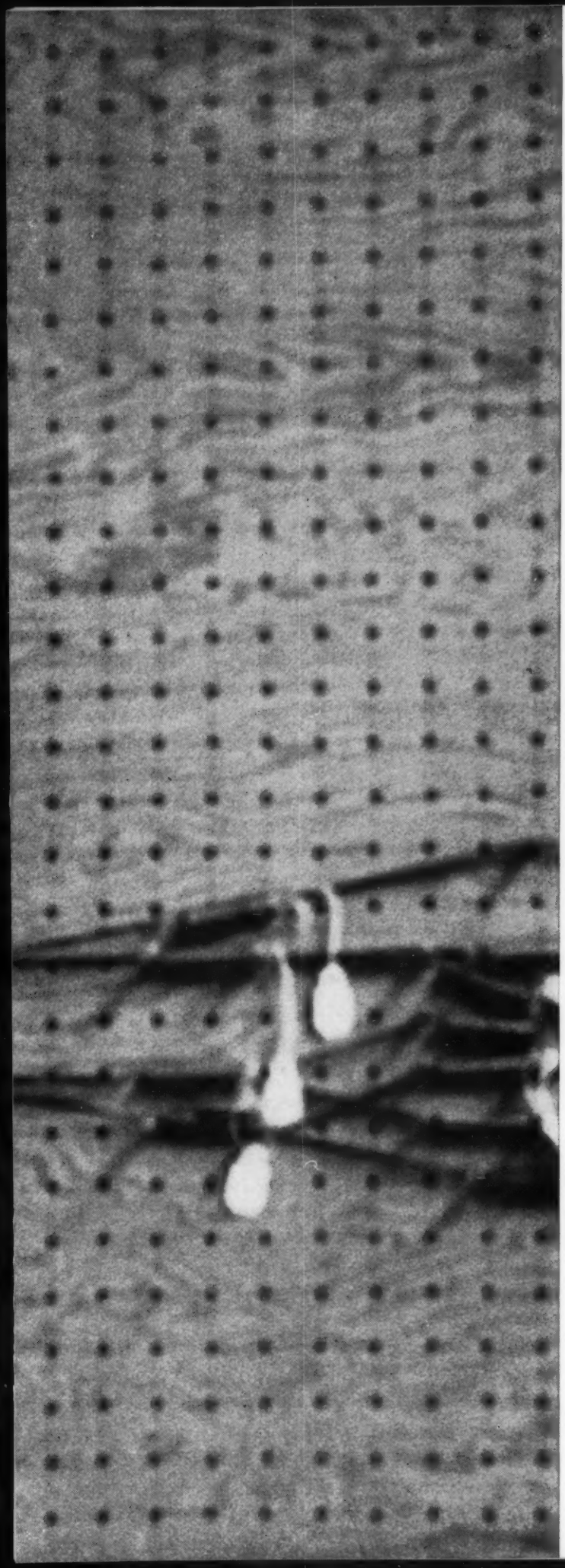

Edward H. Sussenguth, Jr. (B.A., Harvard '54; M.S. in E.E., MIT '59) has investigated the theoretical requirements of an automated design system for advanced cryotron-circuit computers.

HE WORKS WITH A NEW DIMENSION IN COMPUTER DESIGN

Thin film cryotrons may make possible computers of small size and truly prodigious speeds.

The speeds of today's computers are limited mainly by device switching times. Speeds of cryotron computers would be limited mainly by signal propagation times between devices.

Automation of Logical Circuits. Edward Sussenguth has studied methods of design which will reduce the distance between devices to a minimum. He hopes that these will contribute to a completely automatic design system.

Ultimately, then, the systems designer would specify his needs in terms of Boolean equations and feed them into a computer. The computer would (a) design the logical circuits specified by the equations, (b) translate the logical circuits into statements describing the interconnections, (c) from the interconnections, position the devices in an optimal fashion, (d) from this configuration, print out the masks to be used in the evaporation process by which these circuits are made.

This is a big order, but Edward Sussenguth and his colleagues have already made significant progress. Their work may well have a profound effect on computer systems in the coming years.

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A Report by the Editors . . .

THE ENGINEERING STUDENT COUNSELORS

They will reduce the number of needless freshman "bustouts" in engineering. At least that is the goal of the Engineering Student Counselors. The counselors are upperclassmen (there are about sixty of them) who have volunteered to act as big brothers to freshmen who are having trouble. This will be the first fall of service for the group, which is sponsored by Engineering Student Council.

If they succeed, they will render an important service to the College. It is a big loss when a bright young man needlessly fails in his engineering education. It is a loss of his time, of his parents' and the University's investments, and a loss to the nation's technology. We are confident that all concerned with engineering education will be interested in the counselors' success.

Students' Help Needed

At first we wondered, "Why create a new student group? Is there a need for this service?" The answer is yes. Mr. Moyer, Director of Student Personnel, showed us a number of instances which indicate the need. All were bright students, with high SAT scores and good high school records, yet their college records were poor and they left after one year. They probably didn't study effectively, or the complexities of University life just plain had them confused and worried. One boy was a perfectionist. He would struggle long hours to make a quite acceptable physics assignment perfect. Other studies and his health suffered.

"Yes," we thought, "there is a need for something, but why student counselors? Each freshman is assigned to a faculty member who is his advisor. Why couldn't this program be expanded?" Bill Krossner, Chem. E. '61, whose tireless efforts on behalf of Engineering Student Council resulted in the final organization of the counseling effort, had the answer. Basically, it was this: the students have the ability, the time, and the desire. And the freshmen are more comfortable approaching another student for help. Why use the faculty's valuable time?

It is clear that upperclassmen have the ability. The freshmen need to be shown how to study effectively—how to make the most of their out-of-class time—or they have trouble adjusting to the way of life at Cornell. Advice along these lines certainly would have helped the perfectionist mentioned above. Any junior or senior has already wrestled successfully with these problems. And all the counselors have the desire to help. Engineering Student Council is sure of that, since its members interviewed each applicant and chose only those of highest caliber.

Pilot Program Successful

"Will it work?" we asked. "A pilot program last fall was quite successful," we were told. The pilot program was established by Engineering Student Council. Each member of Council endeavored to help one of a list of boys about whom the Dean's office was worried. The program was carefully evaluated, and the Dean's office and all connected with the program were enthusiastic. Bill Krossner had set up this pilot program, and judging from the comments around Council, he did an excellent job.

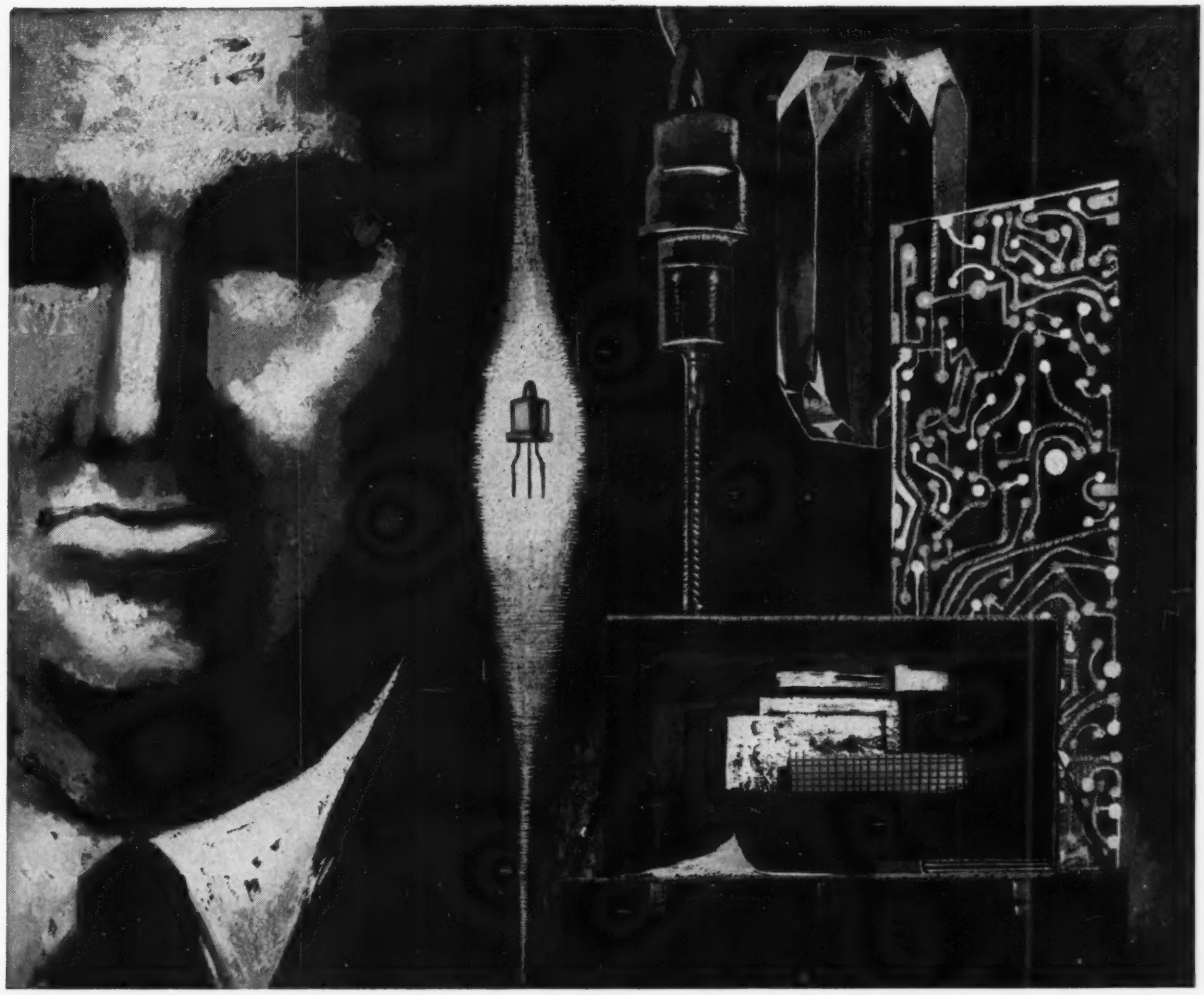
This fall the program will be headed by Bob Franson, EP '62, who will be assisted by Dick Grove, EE '63. They are responsible for administering the program. Bob said that they had two main problems—locating the freshmen who need help in time, and providing the information and assistance that the counselors will need. Many of the faculty have been approached and have offered their help locating those freshmen. Test grades, both prelims and placement tests, and professors' and instructors' opinions will be used. As soon as it becomes evident that a freshman is having trouble, a counselor will be assigned to contact him. Experience has already shown that students are often too late in taking the initiative themselves. That is why the initial contact is being made by the counselor. Of course the freshman may refuse his help. We hope he doesn't.

Counselors' Preparation

The counselors too will need help. They will need information about the freshman they are helping and advice concerning particularly difficult problems. And the curriculum is continually changing. They will have to be brought up to date. A series of lectures on these and other subjects has been started for the counselors' benefit, and the full cooperation of the college has been assured.

Each counselor will be assigned only one freshman (the counselor wants to stay in school too). The method of operation will vary with the personality of the counselor, but the counselors will meet periodically to discuss their problems and report on results.

If one person is helped to the successful completion of his studies all the time and effort will have been worth it. But the counselors will need a lot of cooperation and help. We of the CORNELL ENGINEER wish the Engineering Student Counselors luck and offer our help.
—RTF



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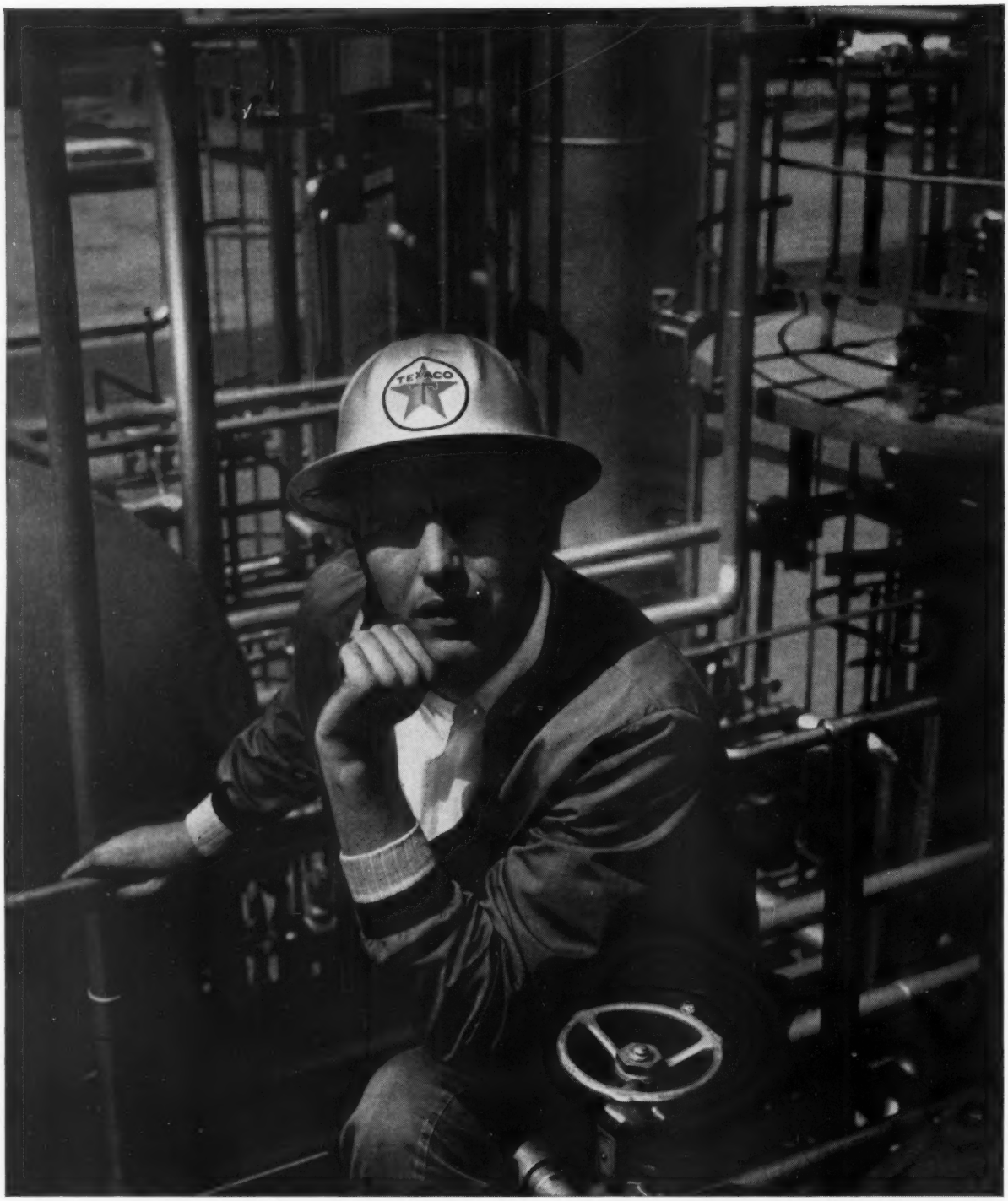

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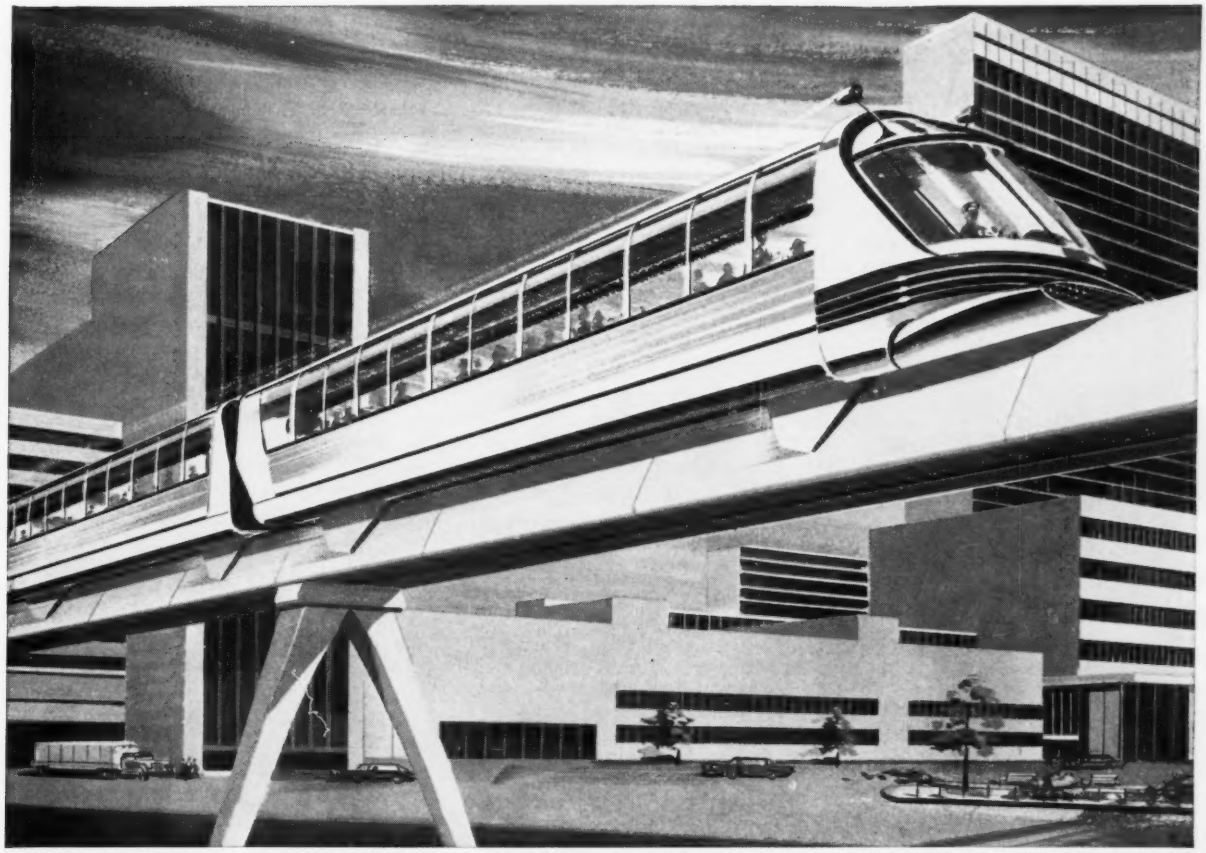

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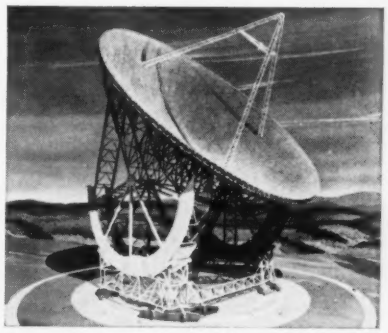

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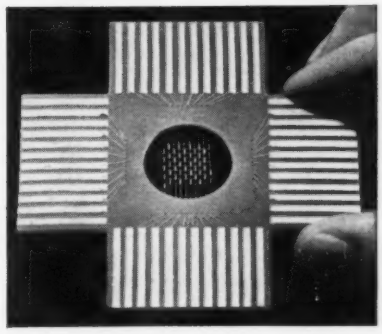

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"The objects of this Society are to promote the welfare of the College of Engineering of Cornell University, and to foster a closer relationship, than would otherwise be the case, between the College and its alumni for the benefit of that institution."

THE PRESIDENT'S LETTER—

Your Officers and Executive Committee are looking forward to another year of interesting and productive activity. The first item is the Annual Meeting of the Executive Committee in Ithaca on September 29 and 30. This will, of course, be past history by the time this reaches you, but, as of this writing, we can say that we are anticipating that most members of the committee will be there and that a productive two-day program has been planned. More on this next month.

We have some new members on the Executive Committee that you should know about–Robert Cowie, B.M.E. '56, M.B.A. '57, Robert C. Findlay, C.E. '42 and Charles H. Stanford, E.E. '47 have been appointed School Representatives. There have also been three changes in the Regional Vice Presidents–Malcolm Hecht, Ch.E. '46, Boston; John B. Ehret, B.M.E. '52, Chicago and John J. Hillsley, Jr., B.S. in A.E.M. '41, St. Louis are the new incumbents.

Our first dinner meeting in New York will be at the Engineers' Club on October 17 at 5:30 P.M. during the A.S.C.E. Annual Meeting. Our speaker will be Frederic C. Wood, C.E. '24, a former President of the Society and currently a University trustee. I hope that all Cornell Engineers attending the A.S.C.E. meetings will join us that evening and renew old acquaintances and make some new ones.

Subsequent dinner meetings as now scheduled are November 30, 1961 during the A.S.M.E. Meeting and January 31, 1962 during the A.I.E.E. Meeting. Put these dates on your calendar and plan to attend if you are in New York. Notices of these dinners will go out to local members only, but all are welcome.

PAUL O. GUNSALUS

ALUMNI ENGINEERS

Edited by
Harry Green III, ChemE '63

Paul O. Gunsalus, Arts '24, begins his second term as president of the Cornell Society of Engineers. Mr. Gunsalus' first year as Society president was marked by several notable accomplishments. Among these were the adoption of a new constitution, and an increase

Paul O. Gunsalus

in the activities of the Boston and Chicago chapters. Under Mr. Gunsalus' administration, the Society strengthened its cooperation with the University by the institution of an annual meeting at Ithaca between members of the Executive Committee and the directors and faculties of the schools, and by donation of $750 for use in an engineering faculty education project.

For the past eight years, Mr. Gunsalus has been assistant vice-president, Operating Staff, of the New York Telephone Company. He has been associated with the company since his graduation from Cornell, and has held various posts, among them special studies engineer, rate engineer, general commercial engineer, and division manager.

A native of New York State, Mr. Gunsalus now resides in Larchmont, New York. Mr. Gunsalus and his wife, the former Louise Gates, have three children, a son and two daughters. In addition to his association with the Cornell Society of Engineers, Mr. Gunsalus holds membership in the Cornell Club of New York and the Larchmont Avenue Church Men's Club, and is a former president of the University Club of Larchmont.

John M. Walsh, Jr., CE '31, has been appointed general superintendent of United States Steel Corporation's Clariton Works in Pennsylvania. Mr. Walsh began his services with U. S. Steel in the blast furnace section in Pittsburgh after his graduation. Then, he became blast furnace superintendent of Edgar Thomson Works, and later, blast furnace division superintendent at Gary Steel Works. In 1957, he became assistant general superintendent of Gary Steel Works, and in January 1961, he began to serve in his present position. Mr. Walsh has two sons, Frank and John M., III, who graduated from Cornell as chemical engineers in 1959. At present, he and his wife live in Clariton, Pennsylvania.

The Cornell Society of Engineers is pleased to announce its meeting schedule for the coming academic year. All meetings are in New York and will be held in addition to the regional meetings in the various other cities.

17 October in conjunction with ASCE Annual Meeting, Fred Wood, C.E., '24, will talk on utilization of space, outer and inner.

30 November in conjunction with the American Society of Mechanical Engineers.

31 January 1962 in conjunction with the American Institute of Electrical Engineers and 3 May 1962, the Annual Meeting at which we will hear from Dean Corson.

Ralph E. Wise, B.Ch.E. '36, vice president and director of sales for the Lummus Company, has been named as a new member of the company's board of directors. Mr. Wise first joined Lummus Company, which designs, engineers, and constructs chemical and other processing plants, in 1945, and from 1950 to 1958, he served abroad in the successive posts of European sales manager, manager of the engineering subsidiaries in Paris and The Hague, and European coordinator for the company. Last year, he took on the added responsibilities of assistant to the president and is presently a member of the board of several of the firm's sub-

Fabian Bachrach

Ralph E. Wise

sidiaries. Mr. Wise is a member of the Cornell Society of Engineers and resides in Bronxville, New York with his wife and three daughters.

Edward D. James, B. Arch. '23, was elevated to Fellowship in the American Institute of Architects in April of this year. Mr. James has been active in local and national committees for the preservation of historic buildings. Among his architectural works are the memorial union building and all residence halls built at Indiana University since 1946, the student union building at Indiana University Medical Center in Indianapolis and the terminal building at Weir Cook Airport, Indianapolis.

Frederick E. Lyford, M.E. '16, recently left for Oslo, Norway where he will take up permanent residence and start an engineering consulting firm. Mr. Lyford retired as president of Merritt-Chapman and Scott a few years ago and became an engineering consultant. More recently, he had served as executive director of The Committee on Engineering Laws, representing forty of the largest U. S. corporations in codifying the vari-

ous state laws affecting their operation.

Alan R. Newhouse, B.E.E. '59, has been chosen for a position in the electrical section of Admiral Hyman G. Rickover's staff in Washington, which is responsible for the planning and building of all U. S. nuclear submarines and surface ships. Mr. Newhouse will be responsible for instrumentation and electrical controls on nuclear submarines. While at Cornell, he was in NROTC, a member of TBII, treasurer and vice president of HKN, a member of Beta Theta Pi, Scabbard and Blade, and Narmid. His undergraduate training included graduate work in radio propagation and microwave theory, and he also worked for the General Electric Company in Ithaca on a satellite tracking project as an undergraduate. He won the Armed Forces Communications and Electronics prize awarded at the Cornell Presidential Military Review in 1960. As a member of Admiral Rickover's staff, he will be working for the Navy Department's Bureau of Ships and the AEC's Division of Reactor Development which is responsible for all nuclear reactor development in the United States.

William L. Everitt, E.E. '21, is the new dean of engineering at the University of Illinois. In April of 1959, he had been one of sixty men chosen from the country's leading scientists, engineers, industrialists and educators to serve on a scientific advisory board which assists the Secretary of the Army and the chiefs of staff.

Channing C. Nelson, B.ChE. '35, PhD. '38, has been named director of the newly created applied mathematics division at Esso Research and Engineering Company in Florham Park. Previous to his new appointment, he had served as the head of the firm's general engineering division.

Irving Itzkan, B.EP. '51, was coauthor of a paper entitled "An Interaction Circuit for Traveling-Wave Tubes," which was published in the Correspondence section of the Preceedings of the IRE. Mr. Itzkan is a senior engineer in the microwave tube research department of the Sperry Gyroscope Company.

Kenneth W. Ashman, EE '33, has been appointed production and materials control manager of the Materials Handling Division of Yale and Towne Manufacturing Company. After graduation, Mr. Ashman held a production management position with IBM, and during WW II, he served as liaison engineer between the armed services and government suppliers of precision instruments. He was with General Electric Company from 1948 until his recent transfer to Yale and Towne in the Philadelphia area.

Gifford L. Weston, EE '26, has retired from his post of Colonel in the US Army after serving for twenty years in the Signal Corps as an engineer. He is now employed at the US Army Signal Research and Development Lab at Fort Monmouth, N.J. Before entering the Army, Mr. Weston had been employed at the Racquette River Paper Co. His daughter is attending Cornell. Mr. Weston now resides in Middletown, N.J.

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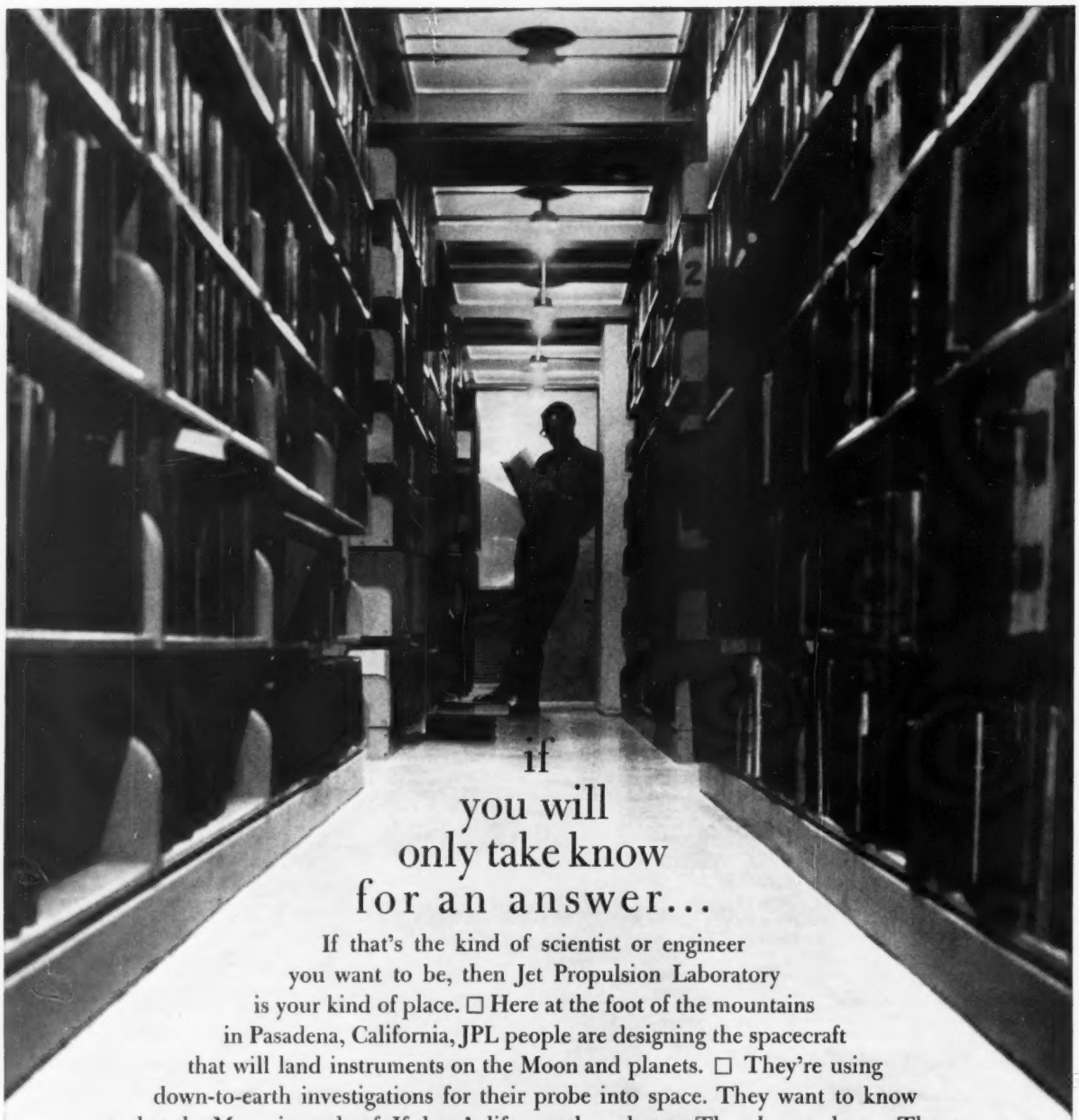

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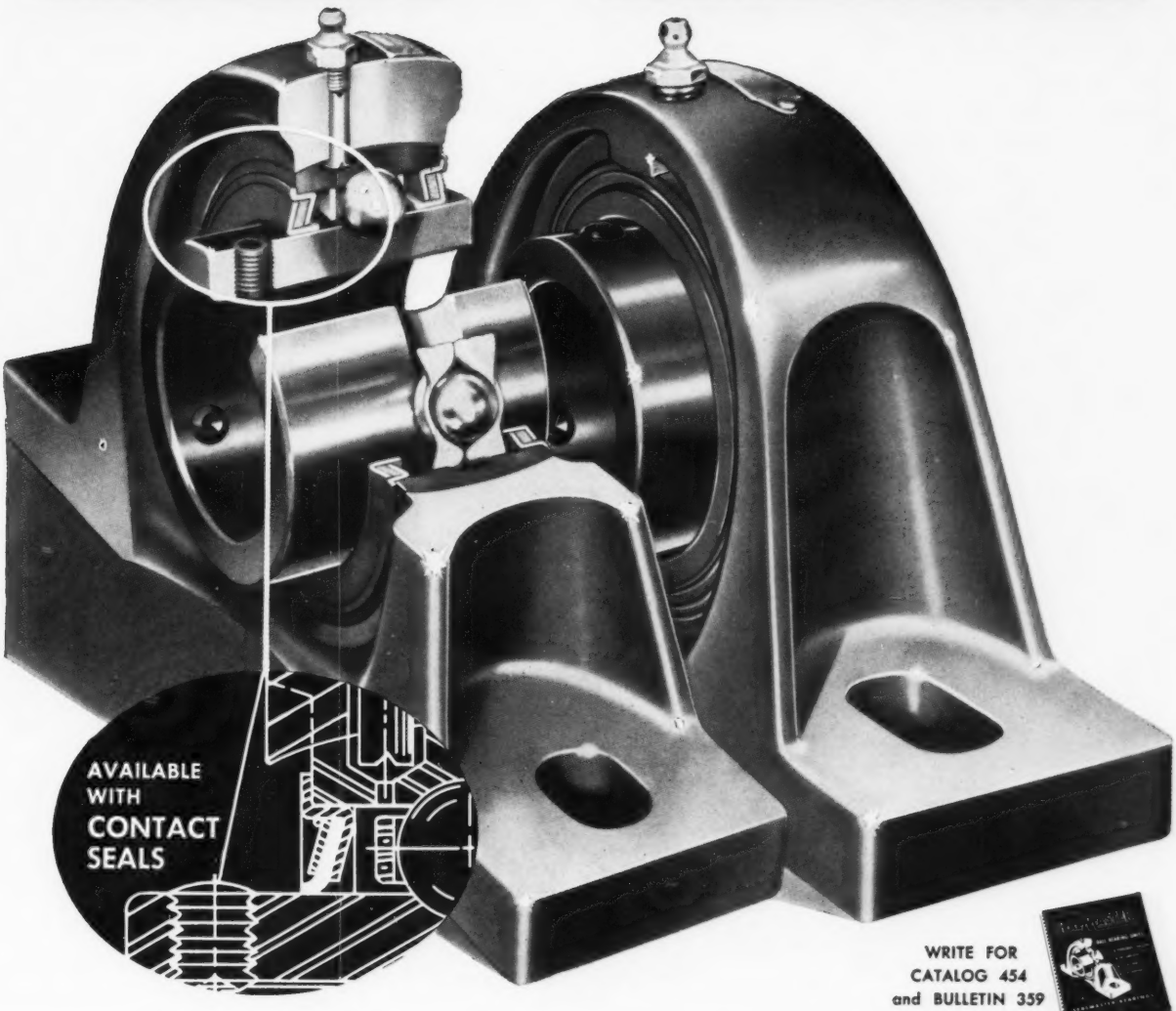

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COLLEGE NEWS

Edited by Mike Goldstein, Arts '64

GIANT RADIO TELESCOPE TO BE READY BY FEBRUARY

The radio-telescope with the largest reflector in the world—1,000 feet in diameter—will be ready to probe the far reaches of the universe by next February. The facility, designed by Cornell University scientists for the Department of Defense, is under construction near Arecibo, Puerto Rico. The telescope will make it possible to study the upper atmosphere, the composition of space and the solar system by radar methods, as well as to send and receive radio signals from the far reaches of the universe.

The excavation for the giant radar dish has been completed and the concrete and steel pylons that will support the feeder system are under construction. The pylons, designed to withstand hurricane winds, will be about three hundred feet tall and thirty feet in diameter at their base.

The estimated cost of the reflector and feed system is $4.1 million, while the entire project will cost $6,500,000, considerably less than similar installations because of the unique design. The Cornell designers have placed the reflector in a natural bowl, eliminating the need for massive steering machinery. The telescope is pointed by rotating the feed line.

Professor William E. Gordon of Cornell is in charge of the design and construction of the facility.

Cornell U. News Bureau

Some idea of the size of pylons that will support the feeder system of the Department of Defense Ionospheric Research Facility near Arecibo, Puerto Rico, can be gained by comparing the form for one of the pylon bases with spectators above. The octagonally-shaped bases will be 36 feet in diameter and will support two pylons 250 feet high and one 365 feet high.

AEC TO PROVIDE FUNDS FOR CORNELL REACTORS

The Atomic Energy Commission will provide $94,000 for fuel fabrication costs of Cornell's Zero Power Reactor now under construction. In addition, the AEC will lend 37.2 kilograms of Uranium-235 and a plutonium-beryllium source for use in the reactor, as well as furnish services for reprocessing the spent fuel elements.

Members of the Cornell faculty contributed extensively to the design of the 10-watt facility, which will be used for research and training in the field of reactor physics. The reactor, which will be ready for operation late this year, will be unique among university facilities as a tool for reactor research. The Zero Power Reactor will be used for studying the basic mechanisms by which a self-sustaining reaction can be produced and used, and for studying the interaction between neutrons and their surroundings. Scientists and engineers will be able to learn how neutrons behave under a variety of conditions. Because it will be a modified critical assembly, it will have a uniquely flexible design for studying reactors themselves.

The Zero Power Reactor will become part of a nuclear laboratory, which also includes the recently completed TRIGA Reactor. The TRIGA training reactor will enable Cornell's science and engineering students to gain first hand experience in the study of nuclear processes. It is also being used in research programs at the University.

The Commission, under its educational assistance program, granted Cornell $150,000 in June, 1958 toward the cost of the TRIGA Reactor. The National Science Foundation two years ago granted Cornell $475,000 to support the construction of the laboratory.

The AEC has granted similar assistance to nine other universities throughout the United States.

FORD INSTRUMENT FELLOWSHIP TO ENGINEERING STUDENT

The Hannibal C. Ford Fellowship for advanced engineering study at Cornell has been awarded to Robert C. Pfahl, M.E. '61.

The Fellowship, one of the most valuable grants for first year graduate study at Cornell, is given by the Ford Instrument Division of Sperry Rand, in memory of Hannibal C. Ford, founder of the com-

pany. It was Ford who adapted computers and automation to the problems of naval gunfire control.

Selected from scores of applicants from engineering schools throughout the country, Mr. Pfahl has achieved an exceptional record as an undergraduate at Cornell.

Cornell U. News Bureau

Robert C. Pfahl, Jr., the winner of the 1961-62 Hannibal C. Ford Fellowship for graduate study at Cornell University. The Fellowship is granted yearly by the Ford Instrument Company division of Sperry Rand Corporation in memory of the company's founder. It is one of the most prized fellowships available for engineering graduate study.

He has been on Dean's List for four years, and is a member of Tau Beta Pi, Pi Tau Sigma, Kappa Kappa Psi, and Phi Kappa Phi, national honorary fraternities. Mr. Pfahl has been a drum major with the Big Red Band and is a member of Acacia fraternity. He plans to major in thermal processes and, after receiving his doctorate, will enter research and teaching.

SATELLITE PHOTOGRAPHY TO BE STUDIED BY CAL

Problems of photography such as those encountered by artificial earth satellites will receive a stepped-up attack by the Cornell Aeronautical Laboratory in Buffalo. Ira G. Ross, CAL president, explained that special equipment will be required to process and maintain the sophisticated photographic apparatus to be used for research in high-acuity photography.

A dust-free photographic laboratory, known as a "white room" is necessary when processing aerial photographs. Mr. Ross noted that reconnaissance photographs taken from altitudes of more than 100 miles are often obscured by dust particles settling on the emulsion during development. The Board of Directors of CAL approved Mr. Ross' recommendation that such a facility be built.

Members of the board also heard Dr. Alexander H. Flax, Cornell Aeronautical Laboratory's vice-president and technical director, describe the laboratory's growing stature abroad and its increased recognition here. He noted that CAL had designed and built the world's first hypersonic shock tunnel in 1950. Now such facilities are in operation all over the United States, as well as in many foreign countries.

In addition, Dr. Flax observed that many processes first developed at CAL are now in use in industry and numerous research organizations.

NUCLEAR POWERED SPACE PROPULSION

A new, more efficient plan for nuclear powered space vehicle propulsion involving super-heated hydrogen as a propellant has been proposed by two aeronautical engineers at Cornell University as an alternative to the chemical units in use now.

The use of hydrogen and helium in their nuclear power plant scheme provides higher specific impulse than was possible before, according to Cornell's Prof. Edwin L. Resler Jr., Graduate School of Aeronautical Engineering, and Prof. Nicholas Rott, formerly of Cornell.

Current rocket fuels are rated by their specific impulse (thrust per unit of fuel flow). Specific impulse times the weight flow of propellant in pounds per second equals rocket thrust.

By today's standards a specific impulse of 300 seconds indicates an extremely good fuel. Professor Resler said that the system he and Professor Rott have developed will provide 750 seconds of specific impulse—even after making allowances for probable power losses.

Scientists already have had to exhaust their ingenuity to fashion enormous chemically powered rockets to make possible escape from earth's gravity. These rockets have been able to thrust only relatively small payloads into the near reaches of space.

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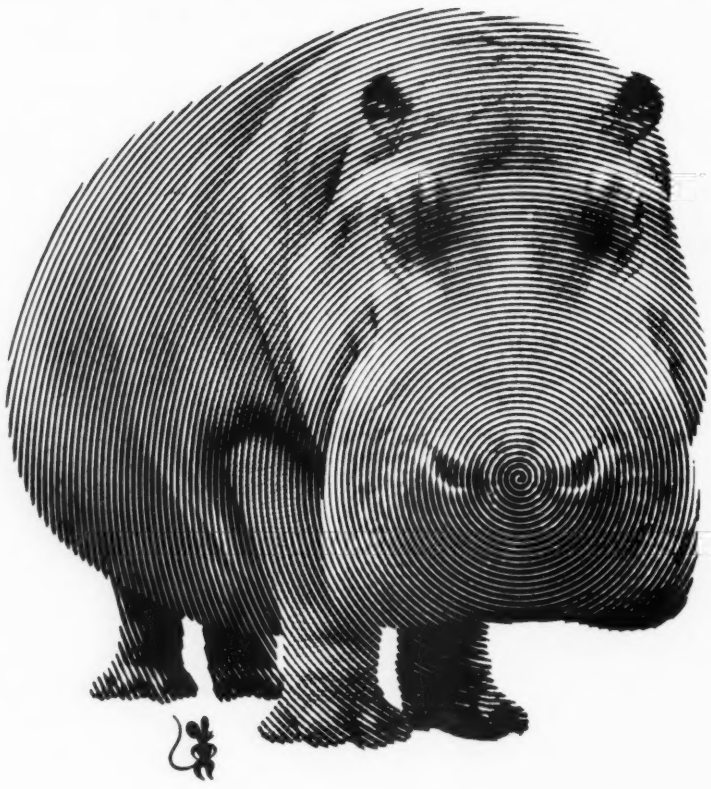

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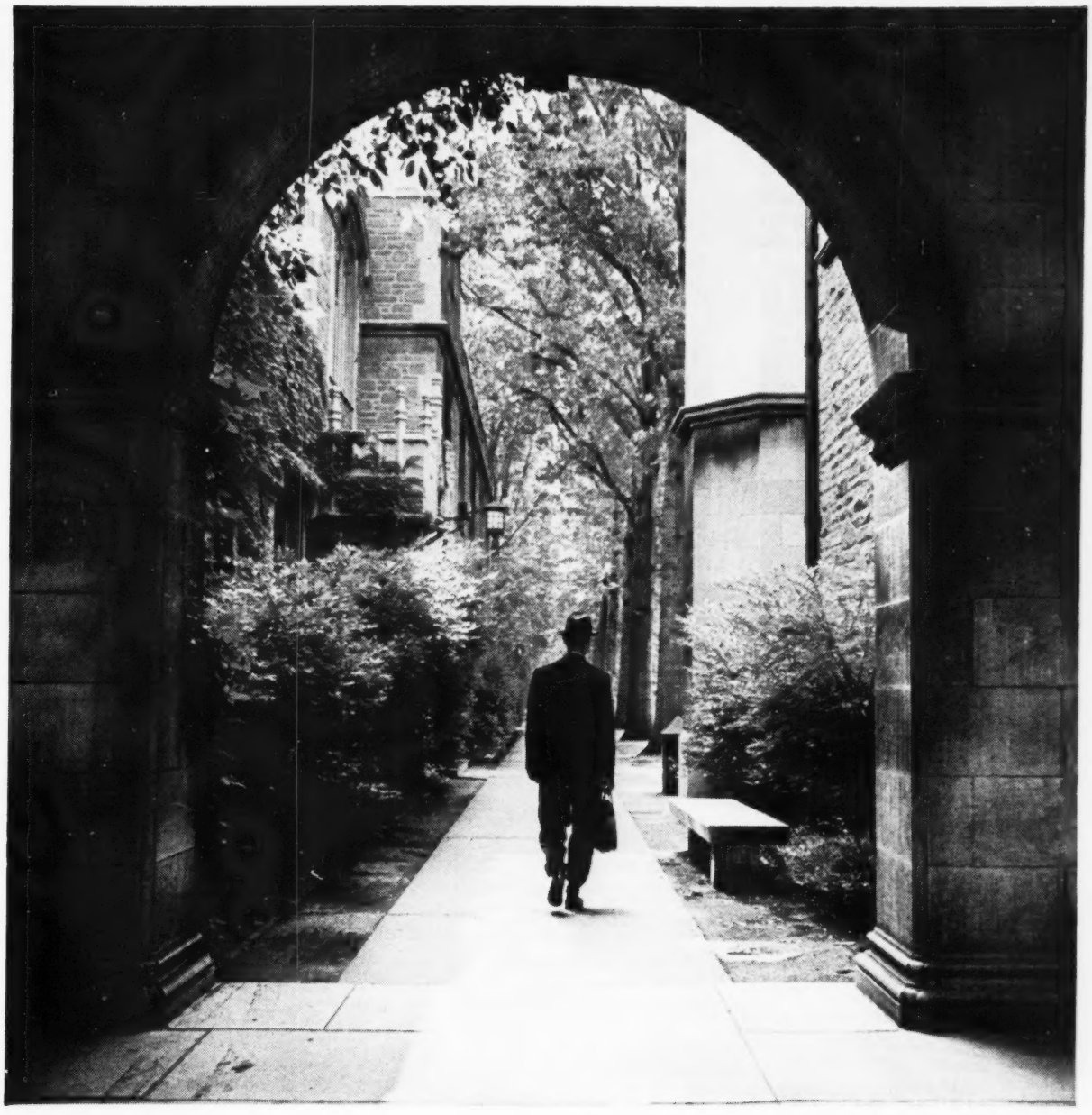

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TECHNIBRIEFS

Edited by William D. Nickles, Jr., EE '65

INFRARED STAR ATLAS

A new type of atlas valuable for development of systems for space navigation, is being prepared by Eastman Kodak Company in Rochester, N.Y., under contract with the Army Rocket and Guided Missile Agency in Redstone, Alabama.

The project, part of which will be completed in about six months, will chart the infrared radiation of known stars. This is the first time equipment has been available for such sensitive infrared mapping.

Special infrared sensing equipment made by Kodak and attached to the 69-inch reflecting telescope at Ohio State University records the radiation. Work with this equipment has yielded the first stellar information ever obtained in the middle wavelength portion of the infrared spectrum. New equipment is now being built for recording longer wave length radiation. This equipment may also be used on other large telescopes such as the 100-inch at Mt. Wilson.

One purpose of the Kodak program is to determine the relation between a star's visible radiation and its infrared radiation.

Astrophysicists have recently theorized that the celestial sphere may contain large numbers of very cold stars, invisible to the eye, but detectable in the infrared. Kodak is now considering extending its work to build an infrared photometer that will have a wide enough field of view to search for these "cold" stars.

NEW RADAR DEVELOPMENTS

A new and simple radar system that can measure both range and speed of a single moving object among a multitude of stationary objects was described at the 13th annual National Aerospace Electronics Conference of the Institute of Radio Engineers by Ole K. Nilssen of Ford Motor Company's Scientific Laboratory.

One of the possible uses for the new system may be found in obstacle sensing equipment for automobiles. Other future applications for this radar may be found in equipment to give aircraft pilots a more accurate measure of the distance from wheels to ground during landing, in proximity-fusing systems or in short-range surveillance devices with which infantry can detect personnel movement in wooded terrain.

For all practical purposes, the range-measuring radar is accurate even at very short distances where regular radar runs into difficulty. There is no basic limitation on the method's long-range capabilities.

A significant difference between the new Ford system and commercial radar is that the Ford system employs the Doppler effect caused by the reflection of extremely high frequency radio signals from a moving target in combination with phase modulation of the transmitter signal, thereby creating two separate signals instead of one. By comparing a ratio of the amplitudes of these two audio frequency signals, the distance between the target and the radar equipment can be obtained.

The target's velocity may be obtained in terms of the frequency of either of the two Doppler signals. The relative speed need not be very high—motion of only a fraction of a mile per hour is sufficient for a measurement to be made.

The equipment needed for this system is much simpler than standard radar equipment. The number of microwave components has been reduced to the smallest possible number, and this lowers the expense of the system as well.

This new radar method is an outgrowth of the Ford Scientific Laboratory's fundamental studies of temperature, pressure, structure of materials and other basic phenomena which ultimately may lead to new automotive technology.

NEW INSTRUMENT MEASURES CYLINDER PRESSURES

A new mechanical indicator specifically designed to accurately measure peak compression and combustion pressures in high-speed diesel engines has been introduced by Kistler Instrument Corporation.

Readings are displayed on a micrometer-type scale which is graduated from zero to 2000 psi in increments of two psi. Completely self-contained, the pocket size gage consists of a differential piston and cylinder in which the measured pressure is opposed by a spring force which varies with the setting of the micrometer thimble. The piston travel, about 1/64 inch, is transmitted to a plunger projecting from the end of the micrometer thimble, where the plunger motion is detected by the user's finger.

In operation, the indicator is pre-set to a reading in excess of the peak pressure to be measured and inserted into adaptors previously installed in the engine. With the finger resting on the sensing plunger, the micrometer thimble is rotated in the direction of decreasing pressure. When the differential piston pulses the sensing plunger it indicates that the peak pressure equals the setting of the gage. The indicator is then removed from the adaptor (which contains a check valve), the reading is noted, and the indicator is again pre-set for the next reading.

ALL-WEATHER TV CAMERA

The world's most rugged television camera has been built to withstand weather, shock, vibration, noise, salt spray, dust, and other extremes of environment without an auxiliary protective housing.

This instrumentation camera is applicable for wide industrial usage in mines, chemical plants, oil refineries, powder plants and other areas where a high performance, rugged camera is needed.

Weighing only 15 lbs., the camera is 16 inches in length and 6⅝ inches in diameter, and is the only camera known today which requires no additional housing to operate in all environments where the equipment conceivably could be used.

The camera will operate with no limit on altitude, making it ideal

for space chamber and flight test applications where conditions of low pressure are encountered.

SHOCK TUBES STUDY PLASMA KINETICS

Head-on collision of two shock waves traveling eighty times faster than sound has been achieved in a hydromagnetic tube made of glass. Scientists developed this unusual use of glass piping in a study of high temperature gases. The glass tube is 12 feet long and 6 inches in diameter. Because the tube is transparent, still photographs can be taken of the colliding shock waves. At impact, the Pyrex piping is brightly illuminated.

The shock waves are driven through the glass piping by a surge of electrical power equal to the output of four Grand Coulee Dams. The electrical energy used to create the waves is stored in two 20-capacitor banks rated at 20,000 volts with a combined peak power of between 2,500,000 and 5,000,000 kilowatts. Once triggered, the shocks last only a few microseconds, but create a gas temperature within the tube of approximately one million degrees.

The shock tube program could have important results in the development of effective ion and plasma-propulsion systems.

ROBOT "MECHANIC"

Research specialists in aviation have come up with the idea of a robot, earthbound "mechanic" which will diagnose maintenance trouble and suggest repair procedures for spaceships that have developed in-flight troubles.

The core of this robot service station would be an electronic computer which would store all data pertinent to the operation of the spaceship. When trouble develops, the astronaut relays information on the difficulty to the service station, which then diagnoses the trouble and relays back repair information. If the diagnosis is critical, the computer would also be able to issue a "May Day" warning to the astronaut and crew, indicating that emergency steps should be taken.

MACHINE PREDICTS TWINS

Electrically recorded heartbeats of the unborn, detectable as early as eleven weeks, are proving useful in prediction of multiple births and other problems of pregnancy.

S. D. Larks, biophysicist at the University of California Medical School at Los Angeles, has identified twenty-five sets of twins, one set of triplets and a set of quadruplets with a fetal electrocardiography procedure which he developed.

Work with the sensitive electrical procedure for recording the unborn's heartbeats has shown that the heartbeat can be detected as early as eleven weeks and that the fetal electrocardiogram becomes large and clear suddenly at about nineteen to twenty-one weeks. In these cases it is possible to make a definite diagnosis of multiple pregnancy at this stage.

Fetal electrocardiography thus provides an alternate diagnostic method to X-ray. It is free from the risk of possible radiation damage and can be repeated as often as necessary.

The new procedure has also proved useful in cases in which there was a doubt as to whether the unborn child was still alive. In some cases it has recorded a tiny heartbeat which for some reason was not detectable by stethoscope. In other cases it has confirmed the doctor's suspicion of death.

POROUS GLASS CHROMATOGRAPHY

An experimental new use for porous glass as a medium of chromatography was shown by Corning Glass Works at the Conference on Analytical Chemistry in Pittsburgh, Pa. Although the glass is not produced by Corning as a commercial chromatographic medium, it has been proven effective in the identification of writing fluids and fountain pen inks.

The advantages of glass for chromatography, listed by the company, included: chemical inertness, transparency which enables the chromatograms to be examined optically, excellent resolution at short distances, heat resistance enabling further development of the pattern and acid resistance permitting the use of acidic solvents.

Water has been used primarily in experiments with ink and writing fluid identification, developing the chromatograms in approximately 24 hours, Corning reported. Dilute hydrochloric acid and dilute ammonium hydroxide developed different chromatograms in the same time. The development times of the organic solvents tested ranged from 48 to 300 hours.

The glass used is porous Vycor, Code 7930, a 96 per cent silica glass. Filled with millions of holes, averaging one sixth of one millionth of an inch, it is referred to as "thirsty glass" because of its affinity for moisture. For chromatographic purposes 3" square plates of porous glass are recommended.

MORE ECONOMICAL ATOMIC POWER

Development of a method of fabricating nuclear fuel elements at reduced cost was reported recently by The Babcock & Wilcox Company.

The new technique calls for the vibration of atomic fuel uranium dioxide powder into thin hollow rods which are forged, or swaged, to the final diameter. In the process,

FATLESS FRYING is possible with this new fry pan, thanks to a nonstick surface of "Teflon" TFE-fluorocarbon resin. Called the "T-Fal", the pan is one of the first consumer products utilizing "Teflon." Conventional in appearance, the pan is shallow, round, ten inches in diameter and made of aluminum. The extremely slick surface of "Teflon" is adhered to the aluminum by a special process, making it easy to clean. The only precautions necessary are to use a wooden spatula and moderate heat.

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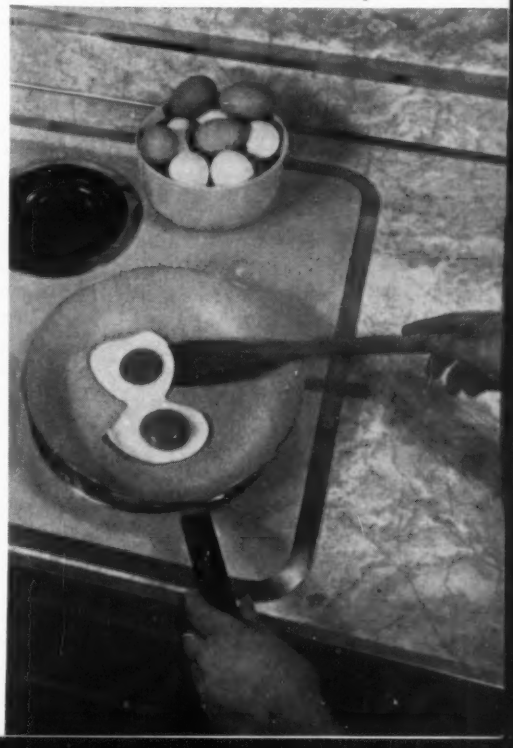

the UO_2 powder is compressed to the required density.

This method of producing fuel elements eliminates such costly manufacturing processes as pressing, sintering, grinding, and inspection of individual pellets. Most oxide-type fuel elements now in use consist of a metal container of thin-walled tubes, or rods, filled with pre-pressed pellets of uranium powder.

Because they show promise of being less expensive to manufacture and have a greater output and longer core lifetime potential, the new elements represent a step toward more economical atomic power, according to B&W representatives.

NUCLEAR-THERMOELECTRIC GENERATOR ANNOUNCED

A new lightweight nuclear generator which converts heat directly into electrical power is undergoing performance testing at the Air Research and Development Command's Air Force Special Weapons Center in Albuquerque, N.M. It was developed under Air Force contract to provide a reliable and long-life power source for facilities such as small unmanned surface radio beacons and weather stations. Designated the NAP-100, the completely portable nuclear auxiliary power device, which weighs less than 40 pounds, was designed and constructed by the new products laboratories of Westinghouse Electric Corporation in Pittsburgh. The generator produces approximately 150 watts of electrical power and was designed for one year of continuous unattended operation. It uses radioactive isotopes, such as Curium 242 as its heat source.

KERR EFFECT

A Kerr cell camera system for use as an instruction aid at the senior and graduate level has been announced by Electro-Optical Instruments, Inc., of Pasadena, California. Designated the KSC-8, EOI's high speed camera system is the first instrument utilizing the electro-optic Kerr effect being offered to educational institutions.

The electro-optic Kerr effect was still an interesting laboratory phenomenon only 15 years ago. Today, it is widely applied in the form of the Kerr cell camera shutter, a device providing the optimum combination of high optical resolution at exposure times in the nanosecond region. Instrumentation of this type has been commercially available for a number of years, but its high cost and complexity have limited its use to government and industrial laboratories.

The Kerr cell shutter consists of a glass cell and two suitable positioned "crossed" polarizers placed before and after the cell along the optical path. The cell contains a liquid, usually nitrobenzene, and is provided with electrodes for establishing an electric field in the liquid in a direction perpendicular to the optical path. With no electric field, the crossed polarizers prevent light transmission. With a field applied, the state of polarization of the light passing through the cell is altered permitting light to pass through the second polarizer.

A complete Kerr cell shutter system consists of a high voltage power supply, a high voltage pulse generating and switching circuit, and the Kerr cell shutter itself. In the KSC-8, both the high voltage power supply and the pulsing circuitry are packaged in a single cabinet. The Kerr cell shutter is connected to the cabinet with six feet of coaxial cable so that the position of the shutter enclosure is flexible.

A low voltage trigger generator incorporated in the main pulser chassis will operate the Kerr cell shutter at a 60-cps rate. It can also be triggered from an externally-generated low voltage pulse or a pushbutton switch.

While the KSC-8 is an educational model, it can satisfactorily be used as an ultra high speed photographic shutter for the same applications as the larger aperture versions. In addition, two Kerr cell shutters, properly sequenced, can be used in a simple velocity of light experiment.

As a high speed shutter, the Kerr cell is used in two ways: When the phenomena under study are self-luminous, the Kerr cell is used alone as is a conventional camera shutter. When the phenomena are non-self-luminous, light must be provided from a spark gap or flash lamp source with the Kerr cell regulating duration of the flash. Typical examples of self-luminous phenomena are: electrically exploded wires; gaseous discharges and breakdown studies. Non-self-luminous phenomena include: hypervelocity particle trajectory and impact studies; shock tube photography.

The Model KSC-8 Kerr Cell Camera can be provided with either of two pulse forming networks in which the electrical length determines the effective photographic exposure time. Additionally, the pulse voltage amplitude is controllable from a front panel dial to allow variations of the shutter transmission pulse. These data are summarized as follows:

Exposure Times Available: 50 nsec. or 100 nsec.

Pulse Voltage Control Range: 0 to 10 Kv.

Kerr Cell Aperture: 4 mm. x 7 mm.

Kerr Cell Length: 30-mm.

FLAW-DETECTION DEVICE MARKETED

A portable magnetic device for detecting cracks and flaws in ferrous metals is being marketed nationally by the Westinghouse X-ray department. This device, the Seal-Lock magnetic crack detector, supplements a number of radiographic and fluoroscopic systems marketed by the X-ray department for use in nondestructive testing.

Designed to meet U.S. Casting Repair's need for an a-c/d-c unit portable enough for use in the field, the 14-pound crack detector is essentially a powerful U-shaped two-pole electromagnet which can be energized from a 6- or 12-volt automobile storage battery or from a 110-volt service outlet through a built-in rectifier.

The detector is placed so that the two poles bridge the area to be examined. When power is switched on, lines of nonreversing magnetic flux flow through the specimen. To make this flux pattern visible, a surface coating of ferromagnetic powder is sprinkled over the 72-square-inch area that can be covered in one test. Since any discontinuities in the metal specimen distort the steady-state magnetic field, the particles align themselves in a pattern duplicating the outlines of any flaws that are present.

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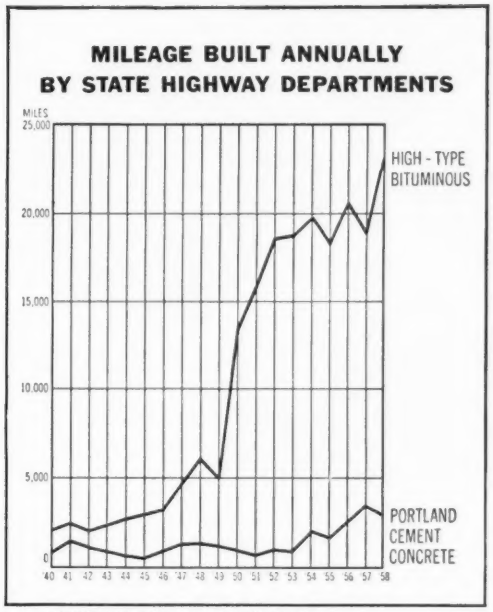

SOURCE: U.S. Bureau of Public Roads

The graph on the left shows you that in 1958 *alone* the use of high-type Asphalt pavement increased *618%* over 1940. This is because advances in engineering know-how, in Asphalt technology and in the development of the mechanical paver have made modern, high-type Asphalt pavement the first choice of highway engineers. Its more economical construction and low maintenance costs have saved many millions of tax dollars and kept America's wheels rolling.

Recent engineering advances have developed new, DEEP STRENGTH Asphalt pavement which will provide even better performance and greater pavement economy in the future.

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Your future success in civil engineering can depend on your knowledge of modern asphalt technology and construction. Send for your free "Student Kit" about Asphalt technology. Prepare for *your* future now:

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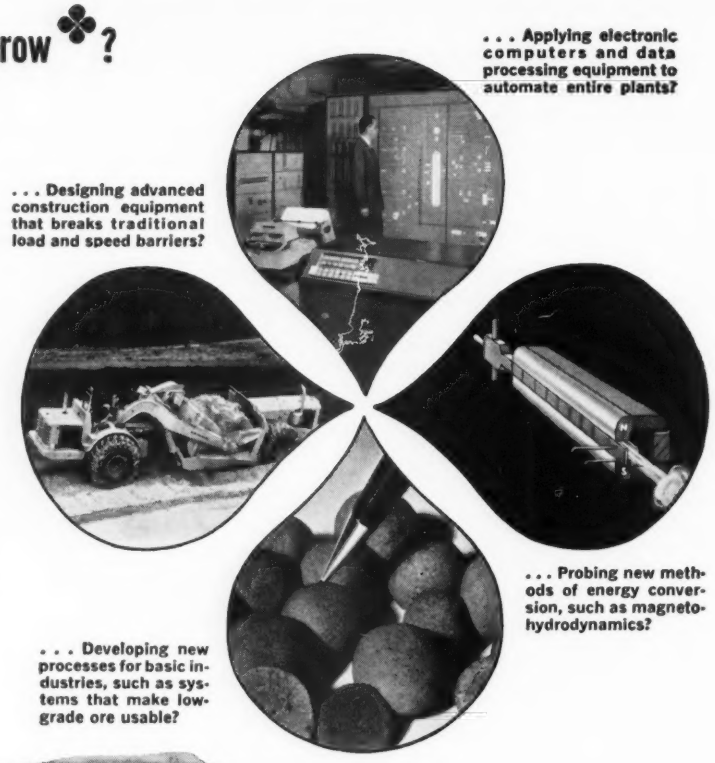

. . . Applying electronic computers and data processing equipment to automate entire plants?

. . . Designing advanced construction equipment that breaks traditional load and speed barriers?

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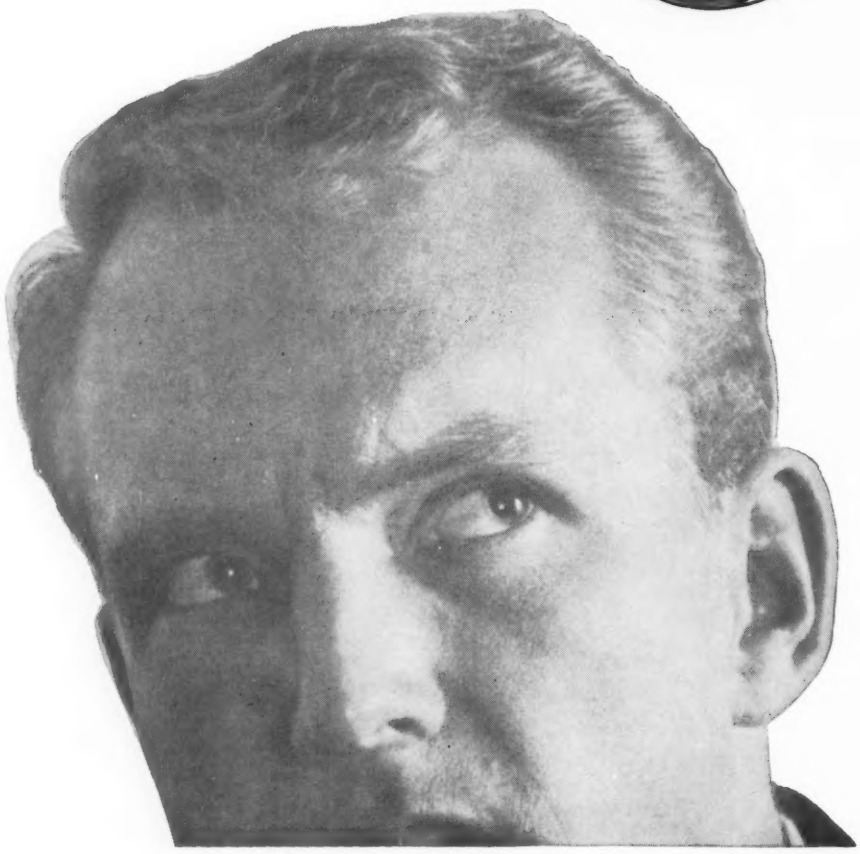
. . . Developing new processes for basic industries, such as systems that make low-grade ore usable?



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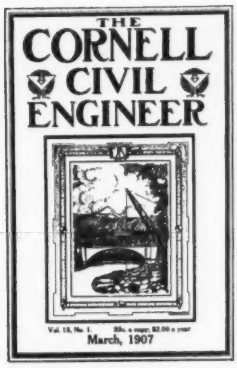

FIFTY YEARS AGO IN THE ENGINEER

Edited by Gary M. Mills, Arts '63

To our subscribers:

The Journal starts the new college year with resolutions for bettering former records as serious as those of the Seniors who are starting on the last lap of their college course and of the Sophomores who often fail to realize that the Freshman year, which they have industriously plowed thru [*sic*], is quite likely to turn out to be the most ambitious of their college years. The Journal has, however, good reasons for looking forward to a year better in many respects than previous years. The present Board has the advantage of the earnest work put into our publication by several Boards and more assistance from the faculty members. We do not intend to introduce any serious alterations in the policy of the Board this year.

We submit the new cover to our fellow Sibleyites for their approval and trust it will stand up against the battery of undergraduate criticism. May it catch many Freshman subscribers.

To the Freshman we want to state that the articles in the Journal will not deal principally with technical details in any branch of engineering. They will be of such general character that most of them can be read with interest by the intelligent Freshman.

—*The Sibley Journal of Engineering, October, 1911*

Editorial: We Need a New Patent Office.

Those who have come in contact with the work of the Patent Office are well aware of the handicap under which it is laboring on account of lack of space and proper facilities for executing its work. The Patent Office building in Washington is quite an imposing structure. It looks like an old Greek temple for lack of a better architectural term, and as far as can be judged from the outside it should be capable of housing a government department of considerable magnitude. As a matter of fact however, it is entirely outgrown and the Patent Office is seriously in need of a new building if the department is to be able to keep pace with the rapidly increasing demands upon it by American inventors and manufacturers.

The scientific library of the Patent Office contains copies of two million patents. These occupy a small section of a corridor and are housed in so cramped a fashion that it is extremely difficult to locate desired documents and otherwise carry out the necessary work of the examiners. The large assignment division is compelled for lack of space to occupy a corridor. None of the clerks in the Office get the required number of cubic feet of air space prescribed by the laws of hygiene. The rooms are low and are occupied by from five to eight persons. Even the basement is being utilized by the office force and the damage done by dust, mice and rats every year is quite considerable. There are rooms occupied by as many as twenty-four persons who are compelled to work all day under artificial light for lack of sunlight.

The department has about 150,000 models stored in the cellars of the House of Representatives, because Congress would not appropriate enough money to house them properly. With the advance in the art of mechanical drafting it is no longer necessary to furnish a model with an application for a patent but previous to this the Patent Office collected an extremely valuable collection of models. The value of these models has been quite generally underestimated. Not only do they constitute a source of popular attraction with visitors on account of their instructiveness in showing the development in all mechanical arts, but they constitute an extremely valuable collection of evidence for use in infringement cases. They have already been called upon to serve this function in the courts in prominent cases.

When it is considered that the archives of the Patent Office contain the most authentic and accurate history of scientific and industrial progress during the last century, the risk of a third destructive fire in the Patent Office should not be tolerated by the manufacturers of the country whose interests are at stake. The inventors of the nation have paid the seven million dollar surplus of the Patent Office and are entitled to have this department put in condition to examine properly the continually increasing volume of inventive work produced in this country.

The late Senator Daniel of Virginia was a faithful worker for the interests of the inventors of the country and he repeatedly introduced a bill for a new Patent Office building on a site immediately north of the Library of Congress, facing the east front of the Capitol. We sincerely hope that the Members of Congress will be put in possession of the facts and that they will favor the erection of this most needed building, in spite of the absence of the political interests which may prompt appropriations for palatial museums and libraries for other branches of the service.

—Cornell Civil Engineer, *October 1911*

HOWARD HUGHES DOCTORAL FELLOWSHIPS. If you are interested in studies leading to a doctor's degree in physics or engineering, you are invited to apply for one of the several new awards in 1962 on the Howard Hughes Doctoral Fellowship Program.

This unique program offers the doctoral candidate the optimum combination of high-level study at an outstanding institution plus practical industrial experience in the Hughes laboratories.

Each Howard Hughes Doctoral Fellowship usually provides about $8,000 annually. Of this amount approximately $1,800 is for tuition, thesis and research expenses, other academic fees and books. The remainder is composed of salary earned by the fellow and a stipend.

Howard Hughes Doctoral Fellowships are open to outstanding students. A master's degree, or equivalent graduate work, is essential before beginning the Fellowship Program.

HUGHES MASTERS FELLOWSHIPS. The Hughes Masters Fellowship Program offers unusual opportunities for education leading to a master's degree . . . and, in addition, provides each fellow with practical experience in the professional field of his choice.

Approximately fifty new awards will be made in 1962 to qualified applicants possessing a bachelor's degree in engineering or physics.

Most of the award winners will be assigned to the **WORK STUDY PROGRAM** and will attend a university sufficiently near a facility of the Hughes Aircraft Company to permit them to obtain practical experience in a professional field of their choice, by working at the company at least half time. An appropriate stipend will be awarded.

A small, highly selected group will be offered a **FULL-STUDY PROGRAM.** Participants in this program will receive fellowships that permit them to attend an outstanding university on a full-time basis during the regular academic year with a substantial stipend.

After completion of the Master's Program, fellows are eligible to apply for HUGHES STAFF DOCTORAL FELLOWSHIPS.

For both programs, typical areas of research and development to which fellows may be assigned while working for Hughes include: weapons control systems, infrared search and track systems, advanced propulsion systems . . . parametric amplifiers, masers, lasers, microwave tubes and devices, electron-tube and solid-state displays, semiconductor materials, antenna arrays, aerospace vehicles and trajectories . . . plasma electronics; solid-state, atomic, nuclear and aerospace physics; propagation, mechanics of structures, chemistry and metallurgy . . . systems analysis, human factors and analysis, network analysis and synthesis . . . microminiaturization, communications, date processing, information theory, simulation.

The classified nature of work at Hughes makes American citizenship and eligibility for security clearance a requirement.

Closing date for applications: January 15, 1962.

How to apply: To apply for either the Howard Hughes Doctoral Fellowship or the Hughes Masters Fellowships write Dr. C. N. Warfield, Manager Educational Relations, Hughes Aircraft Company, Culver City, California.

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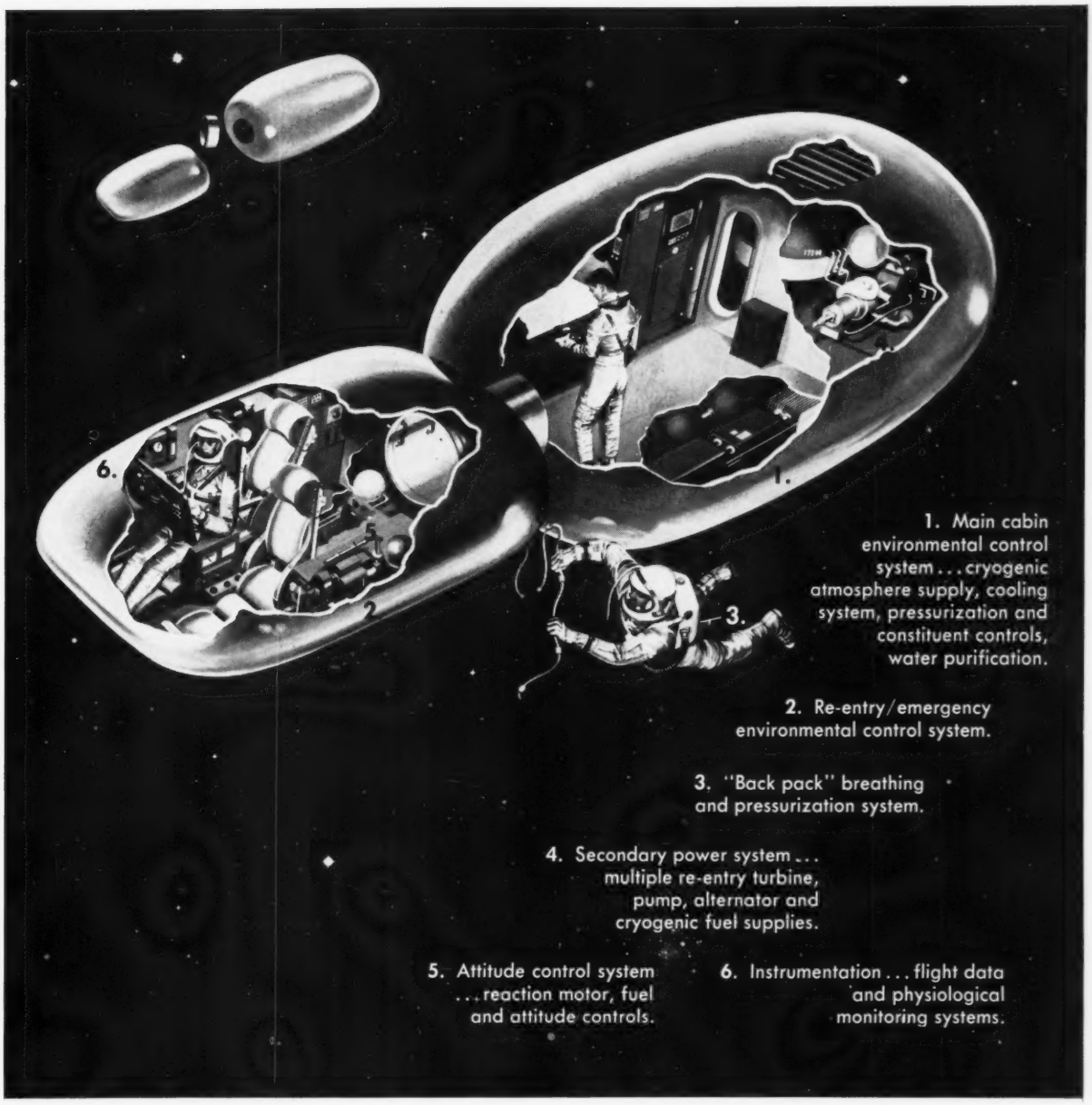
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Manned space flight requires reliable and efficient thermal and atmospheric systems plus secondary power equipment. Complete, integrated systems (such as those pictured above) are under study at Garrett's AiResearch Manufacturing Divisions. Their design reflects 20 years of leadership in airborne and space systems, including NASA's Project Mercury life support system.

Other project areas at Garrett include: solar and nuclear power systems for space applications; electronic systems, including centralized flight data computer systems; and small gas turbines for both military and industrial use.

An orientation program lasting several months in diversified areas is available to every newly-graduated engineer to aid in his placement. It includes working on assignment with experienced engineers in laboratory, preliminary design and development projects.

For further information about a career with The Garrett Corporation, write to Mr. G. D. Bradley in Los Angeles.

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STRESS *and* STRAIN . . .

Edited by Stanley Schloeman, ME '65

There is a tiny beetle-like car which putts-putts around the Tompkins County Hospital with this sign in the rear window: "Premature."

* * *

A clergyman at Cornell who was reading a list of announcements from the pulpit one Sunday, announced at least one meeting for each day of the following week—some times two or three. When he finished, he exclaimed, "Well, it looks like this week is all shot to heaven."

* * *

A secretary, whose boss was dozing in a chair after one too many during lunch hour, said to a caller: "I'm sorry, he's still out from lunch."

* * *

A young lad from that, now, second largest state of Texas, got his father a birthday present; a pipe. It's the one that carries gas from Dallas to New York.

* * *

A Texan is a person who sends CARE packages to his relatives in Scarsdale.

* * *

Young art lovers with status-seeking inclinations have found a way to dress up their walls for entertaining. On blank walls, they hang neat signs reading, "Loaned to such-and-such museum."

* * *

Stopping at the first farmhouse on his famous midnight ride, Paul Revere cried:

"Is your husband at home?"

"Yes!" came back the reply.

"Tell him to get up and defend himself, the British are coming!"

At the second and third and fourth farmhouses the same conversation was repeated, but at the fifth house it went something like this:

"Is your husband at home?"

"No," came back the reply.

"Whoa!"

Professor: "You missed my class yesterday, didn't you?"

Student: "Oh, no sir, not in the least."

* * *

The veteran battleship was in port on exhibition to the public; on its deck was an inscribed bronze plaque.

"And here," said the guide solemnly, "is where our gallant captain fell."

A spry little old lady piped up: "Well no wonder! I nearly tripped on the danm thing myself."

* * *

Girls' dresses have gotton so short we wonder what the designers will be up to next.

* * *

I knew a girl named passion
I asked her for a date
I took her out to dinner,
And gosh how passionate!

* * *

"Down where I lived, said the Texan, "we grew a pumpkin so big that when we cut it my wife used one half of it for a cradle."

"Well," smiled the man from Chicago, "that's nothing. A few days ago, right here, two full-grown policemen were found asleep on one beat!"

* * *

The preacher mumbled a few words in their ears and they were married. A few months later, the husband mumbled a few words in his sleep and they were divorced.

* * *

"Daddy, if you give me a dime I'll tell you what the iceman said to Mama.

"O.K., son, here's your dime."

The son replied, "He said, 'Do you want any ice today, lady'?"

* * *

Bright suggestion for a simplified tax blank: "How much do you have? Where is it? Send it in."

The automobile motor began to pound, and finally stopped. The worried boy friend said to his companion: "I wonder what that knock could be?"

"I dunno," answered the pretty blonde, "but it isn't opportunity."

* * *

President Wilson used to find pleasure in relating how he once had his special car sidetracked at Hannibal, Missouri, so he might make a quiet pilgrimage to the monument erected on the bluff to the honor of Mark Twain. Unknown to the natives, Wilson asked one of them if he remembered Tom Sawyer.

"Never heard of him," the Missourian made answer.

"Recollect Huckleberry Finn?" asked the President.

"Finn? Finn?" mused the native. "There was a family of Finns down the road apiece, but I don't recollect there was a Huckleberry among 'em."

"Do you happen to recall Puddin' head Wilson?" ventured the visitor.

"Oh, yes, sure!" said the native promptly; "I voted for him twice, sir."

* * *

A bachelor is a rolling stone who gathers no boss.

* * *

It was a magic moment under a brilliant moon.

She said rapturously. "Will you love me when I'm old?"

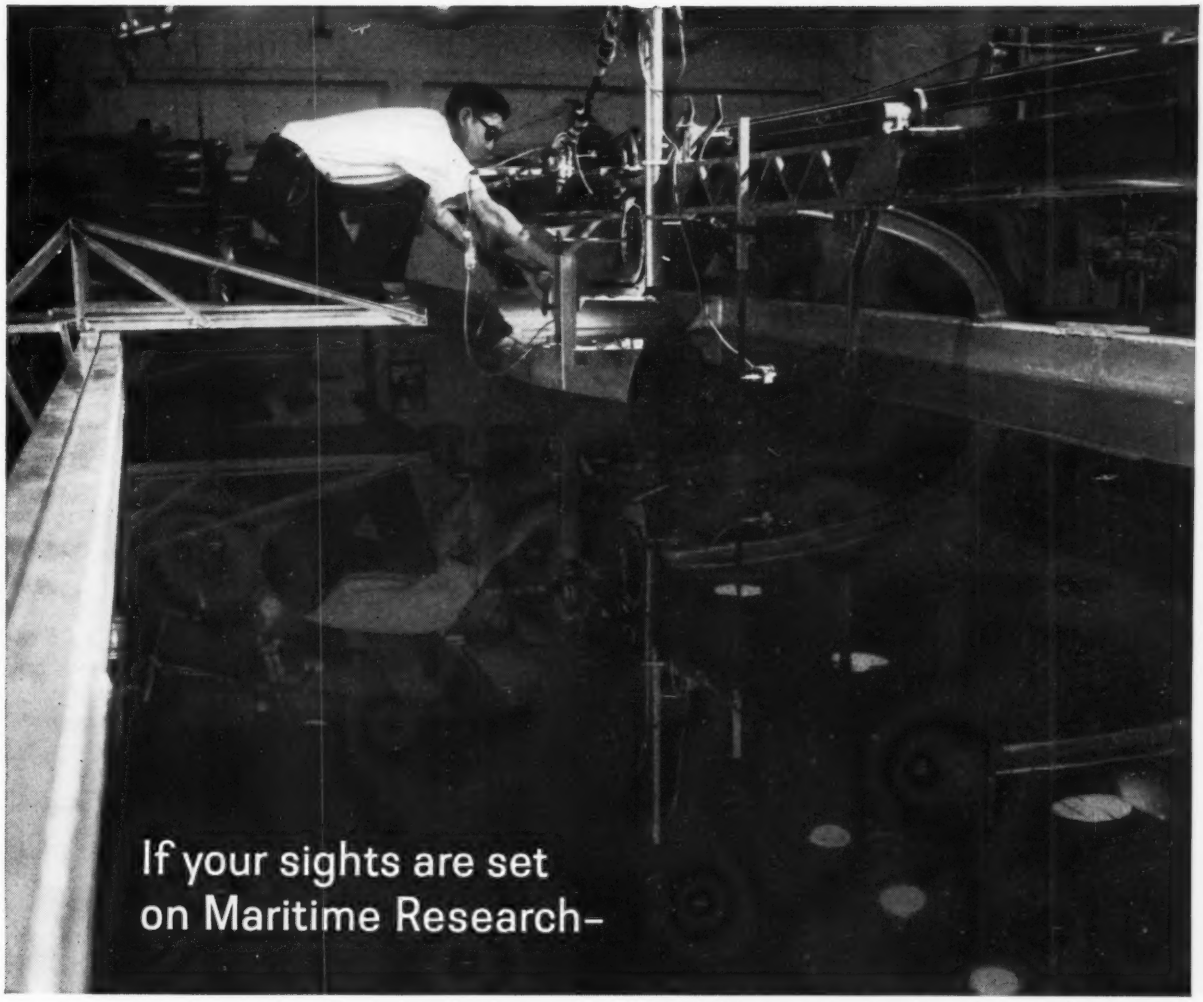
He responded. "Love you? I shall iodolize you. I shall worship the ground under your little feet. I shall always—say, you aren't going to look like your mother are you?"

* * *

The golf professional had been hired by a big department store to give lessons and one day he was approached by two women.

"Would you like to learn to play golf, madam?" he asked one.

"Oh, no," she said, "it's my friend who wants to learn; I learned yesterday."



Technician preparing for motion-picture studies of a model in the testing tank at Stevens Institute of Technology.

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The engineer designing and constructing vessels finds photography one of his valuable tools. Motion-picture studies of models in tanks help in hull design. Electron microscope plates contribute to the proper metallurgy for propellers and other parts. And radiography checks welded seams of hull plate and piping as well as heavy castings for internal imperfections.

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Interview with General Electric's Dr. J. H. Hollomon

Manager—General Engineering Laboratory

Society Has New Needs and Wants—Plan Your Career Accordingly

DR. HOLLOMON is responsible for General Electric's centralized, advanced engineering activities. He is also an adjunct professor of metallurgy at RPI, serves in advisory posts for four universities, and is a member of the Technical Assistance panel of President Kennedy's Scientific Advisory Committee. Long interested in emphasizing new areas of opportunity for engineers and scientists, the following highlights some of Dr. Hollomon's opinions.

Q. Dr. Hollomon, what characterizes the new needs and wants of society?

A. There are four significant changes in recent times that characterize these needs and wants.

1. The increases in the number of people who live in cities: the accompanying need is for adequate control of air pollution, elimination of transportation bottlenecks, slum clearance, and adequate water resources.

2. The shift in our economy from agriculture and manufacturing to "services": today less than half our working population produces the food and goods for the remainder. Education, health, and recreation are new needs. They require a new information technology to eliminate the drudgery of routine mental tasks as our electrical technology eliminated routine physical drudgery.

3. The continued need for national defense and for arms reduction: the majority of our technical resources is concerned with research and development for military purposes. But increasingly, we must look to new technical means for detection and control.

4. The arising expectations of the peoples of the newly developing nations: here the "haves" of our society must provide the industry and the tools for the "have-nots" of the new countries if they are to share the advantages of modern technology. It is now clearly recognized by all that Western technology is capable of furnishing the material goods of modern life to the billions of people of the world rather than only to the millions in the West.

We see in these new wants, prospects for General Electric's future growth and contribution.

Q. Could you give us some examples?

A. We are investigating techniques for the control and measurement of air and water pollution which will be applicable not only to cities, but to individual households. We have developed, for example, new methods of purifying salt water and specific techniques for determining impurities in polluted air. General Electric is increasing its international business by furnishing power generating and transportation equipment for Africa, South America, and Southern Asia.

We are looking for other products that would be helpful to these areas to develop their economy and to improve their way of life. We can develop new information systems, new ways of storing and retrieving information, or handling it in computers. We can design new devices that do some of the thinking functions of men, that will make education more effective and perhaps contribute substantially to reducing the cost of medical treatment. We can design new devices for more efficient "paper handling" in the service industries.

Q. If I want to be a part of this new activity, how should I plan my career?

A. First of all, recognize that the meeting of needs and wants of society with products and services is most important and satisfying work. Today this activity requires not only knowledge of science and technology but also of economics, sociology and the best of the past as learned from the liberal arts. To do the engineering involved requires, at least for young men, the most varied experience possible. This means working at a number of different jobs involving different science and technology and different products. This kind of experience for engineers is one of the best means of learning how to conceive and design —how to be able to meet the changing requirements of the times.

For scientists, look to those new fields in biology, biophysics, information, and power generation that afford the most challenge in understanding the world in which we live.

But above all else, the science explosion of the last several decades means that the tools you will use as an engineer or as a scientist and the knowledge involved will change during your lifetime. Thus, you must be in a position to continue your education, either on your own or in courses at universities or in special courses sponsored by the company for which you work.

Q. Does General Electric offer these advantages to a young scientist or engineer?

A. General Electric is a large diversified company in which young men have the opportunity of working on a variety of problems with experienced people at the forefront of science and technology. There are a number of laboratories where research and advanced development is and has been traditional. The Company offers incentives for graduate studies, as well as a number of educational programs with expert and experienced teachers. Talk to your placement officers and members of your faculty. I hope you will plan to meet our representative when he visits the campus.

A recent address by Dr. Hollomon entitled "Engineering's Great Challenge — the 1960's," will be of interest to most Juniors, Seniors, and Graduate Students. It's available by addressing your request to: Dr. J. H. Hollomon, Section 699-2, General Electric Company, Schenectady 5, N.Y.

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